J R Welsh

PART III.—GEOLOGY AND BOTANY.

REPORT ON THE WORK

OF THE

HORN SCIENTIFIC EXPEDITION

TO

CENTRAL AUSTRALIA.

PART III.—GEOLOGY AND BOTANY.

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PART III.—GEOLOGY AND BOTANY.

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PHYSICAL GEOGRAPHY.

By PROFESSOR RALPH TATE and J. A. WATT, B.Sc.

In dealing with the subject of the physical geography of Central Australia, it is necessary to mention that only a very general and brief outline will be given, as the space available does not permit of anything like a complete account.

It will be dealt with under the following heads:—

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A.—MOUNTAINS.

In the consideration of the physical geography of this country the mountain system should first demand our attention, as being of primary importance, for on it not only does the trend of the main valleys depend but also the size, number, and even the very existence of the rivers, by reason of its influence on the wind and rain. For the above reasons the McDonnell Ranges form the most important physiographic feature of Central Australia. Were it not for the presence of this chain of comparatively elevated land, with its important influence on the meteorology of the surrounding country, the greater part of the interior would resemble a sterile desert, which is the actual condition of portions of the stony and sandy plains after a more than usually prolonged drought.

The most important mountain range within the area under consideration is doubtless that of the McDonnell, which represents the much-denuded crest of one of the highest folds, into which the crust of the earth within this area has been thrown. In the crumpling of the earth's crust the highest anticlines, being on the lines of maximum disturbance, usually have cores of plutonic rocks. This seems to have been the case with a great portion of the McDonnell Ranges, subsequent movements having metamorphosed the originally plutonic rocks, thus causing doubt as to their eruptive origin.

The mountain system of Central Australia does not consist alone of the McDonnell Ranges and those immediately associated with them to the north and north-east, as the Hart and Strangways Ranges, but includes also a number of parallel ranges lying to the south, such as the James, Waterhouse, George Gill, Levi, and Chandler Ranges, all representing the arches or troughs of the folds produced by earth movements in past geological time. Examples of ranges occupying the troughs of the earth-folds are to be found in the case of the George Gill and Levi Range. In each of these ranges, which really are portions of one and the same range (their continuity being broken merely by the transverse valley of Trickett Creek, a tributary of Petermann Creek, the latter a branch of the Palmer), the rocks occupy a perfect synclinal trough, in which the sandstone dips from the north and south towards the centre of the range at an angle of from 10° to 20°

The mountain system of Central Australia may be conveniently treated in three divisions, the mountain ranges in each division for the most part comprising rocks of one and the same geological age, while they differ from those of the other divisions.

Thus (1) the McDonnell Ranges proper, as well as the Hart Range, are situated wholly, or nearly so, within the area occupied by metamorphic rocks of presumably Pre-Cambrian age ; while (2), the James, Waterhouse, George Gill, and Levi Ranges are wholly contained within the country occupied by Ordovician strata ; and lastly (3), the low table-topped hills and groups of them, which one feels disinclined to dignify with the name of mountains and mountain ranges, are entirely formed of Cretaceous strata. Now, as each of these geological systems are represented by rocks differing in lithological character and structure, while they have suffered differently from the dynamic forces of nature, the physical features of the ranges occupied by strata of these different geological systems differ widely, and will therefore be described separately.

(1) The McDonnell Ranges.

Dealing with the features of the most important first, we find that the McDonnell Ranges trend in a nearly east and west direction for a distance of about 400 miles, and have a width varying from twenty to fifty miles, thus covering an area of more than 10,000 square miles.

In the meridan of Alice Springs Telegraph Station, which is situated from three to four miles north of Heavitree Gap, where the River Todd breaks through the southern boundary of the ranges under consideration, they have a width of about twenty miles.

Westerly from this point they extend as a rugged main ridge, containing the most elevated peaks, often capped by Ordovician quartzite, with a band of varying width of "jumbly" hills flanking this main ridge on each side. About the longitude of Mounts Liebig and Palmer (*i.e.*, about 131° 15′) the range becomes much broken up.

Easterly from Alice Springs the range extends to about 136° east longitude; at 134° 10′ it becomes confluent with the south-east extension of Strangways Range, with which it may be further considered to be linked by the Georgina Range, about 134° 20′; while further east (about 135°) it is joined by Hart Range. It may be said to extend approximately from the 130th to the 136th meridian of east longitude, a distance of nearly 400 miles, and to lie between 23° 7′ and 23° 35′ south latitude, with an average width of between twenty to thirty miles.

These ranges have a very irregular outline, and have no parallel longitudinal valleys; in fact, they present in no degree that uniformity of physical features produced by earth movements and meteoric agencies, so familiar in the case of the Ordovician ranges.

The original stratification of the once sedimentary strata and the joints, that were perhaps present in the original granites, have played to all appearances no part in the moulding of the present physical features out of the metamorphic rocks, the age of which is considered to be Pre-Cambrian. Rising abruptly out of the elevated area of the McDonnell Ranges, with no linear arrangement, but irregularly distributed, are a series of eminences, whose summits are in some cases, as in that of Belt Range and Mount Sonder, capped by a northern extension of Ordovician quartzite. To the presence of this protective covering, which has effectually warded off the levelling forces of nature from the underlying less weather-resisting metamorphic rocks, is probably due the comparative elevation of these peaks.

Ranged in order west to east the altitudes above sea level of the chief peaks are as follows:—Mount Edward in Belt Range, 4649 feet; Mount Heughlin, 4756 feet; Mount Zeil, 4040 feet; Mount Sonder, 4496 feet; and Mount Giles, 4210 feet.

The average elevation of the surrounding country is over 2000 feet above sea level, so that these mountains are not so prominent as one might be inclined to imagine judging alone from their altitude above sea level. They are nearly all accessible, as the slopes are not usually very precipitous, except for example the Belt Range (Fig. 3).

The movements of the earth's crust, to which these ranges bear witness, were to a great extent of Pre-Ordovician age, and were continued, though much diminished in intensity, down to Post-Cretaceous times. During the earlier part of the Ordovician period the Pre-Cambrian rocks probably underwent subsidence, so as to allow of the deposition of Ordovician sediment that originally covered much at least of the area now occupied by Pre-Cambrian rocks. Later they partook of the Post-Ordovician upheaval, which converted much of the area occupied by Ordovician sea into dry land. Later again this area has probably participated in the gentle and gradual Post-Cretaceous upheaval, to which are attributable the very slight undulations in the Desert Sandstone.

The extreme metamorphism of the Pre-Cambrian rocks is to a great degree Pre-Ordovician; but, as indicated by the gneissic character of much of the intrusive granites, it was partly at least contemporaneous with that of the Ordovician quartzites, etc. As should, perhaps, have been pointed out previously, the elevated area occupied by the McDonnell Ranges forms a great part of the northern boundary of the Lake Eyre Basin. In travelling southwards from this elevated region towards the centre of the basin, we descend by means of a series of terraces

formed by the Ordovician ranges, each one on a lower level than its predecessor on the north, on to wide and extensive plains occupied by Cretaceous rocks and by stony and loamy plains and sandhills.

These last features have been formed from the *débris* derived partly from the Cretaceous strata, which *débris* has been accumulating through the Late-Tertiary and Post-Tertiary epochs, and is still accumulating at the present day. Such plains, near their northern limit at least, are not less than 1000 feet above sea level. Still they slope so gently to the south towards the centre of the basin, *i.e.*, towards Lake Eyre, that their elevation above sea level is no index to their altitude above the surrounding country. The streams which have eroded them have not generally excavated their channels deeper than from 200 to 250 feet below the original surface of the country.

(2) The James, Waterhouse, George Gill and Levi Ranges.

The next division of the mountain system includes the ranges situated within the Ordovician area. Beginning from the north these comprise the quartzite ridge which forms the southern boundary of the Pre-Cambrian area, and in which are the Heavitree, Emily, Temple Bar, etc., Gaps. This ridge is succeeded on the south by the Waterhouse, James, George Gill, Levi and Chandler Ranges. These ranges consist of a series of parallel ridges of quartzite and sandstone, with a nearly east and west trend, separated by numerous parallel and often very persistent and regular longitudinal valleys. These valleys are generally very narrow, often less than a mile wide, but sometimes open out, as in the case of the Missionary Plain, to a width of from twelve to fifteen miles.

Intersecting these ranges are numerous short transverse valleys, frequently entirely occupied by the channels of the creeks, which have eroded them. One of these creeks often extends for long distances along one of the longitudinal valleys, and then suddenly bursts through the range through a narrow gorge, to resume its course along a second longitudinal valley at a lower level than the first, and perhaps to pass through a second gorge in its passage towards Lake Eyre. These ranges extend easterly, as far at least as those of the previous division have been traced, while westerly they practically terminate at 131° 20′ (about) east longitude.

They have a mean combined width, if we include the intervening plains and valleys, of from sixty to seventy miles. The area occupied by them, therefore, must be more than 15,000 square miles. The highest points are situated in the most northern ridge, as in the case of Mount Gillen, which must be nearly 3000

feet above sea level. The mean elevation of this ridge is about 2500 feet above sea level, that of the Waterhouse Range about 2200 feet, that of the James Range about 2000 feet, while lastly the mean elevation of Chandler Range is only about 1500 to 1600 feet. From these figures it can be clearly seen that there is a gradual decrease in elevation in the ranges from north to south, each range to the south constituting, as it were, a step in the descent from the McDonnell Ranges to the plains.

The chief factors, in addition to the position of the longitudinal valleys occupying the original troughs of the folds, that have influenced the direction of the lines of denudation are (1) the lines of weakness on the crowns of the anticlinal arches, and (2) the position of the bands of limestone. An example of the influence of (1) is furnished by the valley of Petermann Creek, which has been eroded out of an anticlinal arch, while the rocks of the corresponding synclinal trough now form the George Gill and Levi Ranges. The influence of (2), as might have been expected, is to be observed throughout this region, the greater number of the valleys within these ranges having been, to a great extent, eroded out of the limestone beds.

The angle of inclination of the mountain slopes depends to a great extent on the nature of the strata and on their dip. On one side of the ridge the slope often conforms to the dip of the strata when these are inclined at fairly steep angles. On the south side of the quartzite ridge, for instance, which forms the northern boundary of this area, the inclination of the strata (quartzite and limestone), as well as that of the mountain slope, is from 60° to 70°.

The north face of this ridge, however, presents for almost the total thickness of the quartzite a sheer perpendicular escarpment extending from the summit downwards 200 or 300 feet. Below this quartzite, as at Mount Gillen, the remaining 600 to 700 feet of this face, composed of Pre-Cambrian gneiss, has a slope not exceeding 30° to 40°. A similar difference in the inclination of the slopes of a ridge is also to be seen in the case of the Mereenie Escarpment, which probably extends almost continuously as far east as the Finke River. On the north side there is a steep, almost perpendicular, escarpment from 500 to 600 feet high, whereas on the south the slope conforms to the dip of the strata.

In those ranges, where the sandstone is dipping at very low angles, as in the George Gill and Levi Ranges, we find very steep, almost vertical, escarpments on both sides. The northern face of Levi Range, for instance, rises to an elevation of about 500 feet above the valley of Petermann Creek, for nearly 300 feet of

which it is almost vertical. At the foot of this escarpment there is a talus slope nearly 200 feet high, with an inclination of about 30°.

(3) Cretaceous Table-topped Hills and Table-lands.

Although there are no mountains or mountain ranges worthy of the name within the Cretaceous division, the altitude of the Cretaceous plains near the northern limit of this area is as much as 1000 feet above sea level. These elevated plains slope gradually towards Lake Eyre from an altitude of 1000 feet above sea level to thirty-nine feet below sea level at Lake Eyre.

Rising out of these plains are numerous table-topped hills and low flat ranges and table-lands, isolated from one another by denudation. Some of the highest of these rise to an altitude of from 300 to 400 feet above the surrounding plains, and thus in the northern part of this Cretaceous area to 1200 to 1300 feet above sea level. These isolated masses are separated by "stony" and "loamy" plains and "sandhills." The hills are usually crowned by a layer a few feet in thickness of an exceedingly hard rock, representing sometimes a sandstone, sometimes a grit, and at other times a finer-grained and more argillaceous rock. Between the grains of this rock hydrated silica has been deposited from solution. To the presence of this cement is to be attributed its extreme hardness and often more or less conchoidal fracture. This so-called "desert sandstone," or porcellanite, when finer-grained and more argillaceous, protects the under-lying strata from denudation in a way that may be compared to the protective action of the boulders in the case of the famous earth-pillars of certain villages in the Tyrol.

Chambers Pillar, for instance, a well-known feature situated ten miles north of the old Idracowra cattle station on the Finke, might be likened to an earth pillar, the indurated ferruginous sandstone of its summit taking the place of the boulder of the earth-pillar, and protecting the sandstone of the pillar from removal by denudation. The isolation of Chambers Pillar, for it is surrounded on all sides by red sandhills, is probably due to the purely local character of the indurating process, or rather perhaps to the induration having been more intense in the locality of the Pillar, than in the once surrounding rock, now entirely denuded. The Pillar, if we include in this term the whole structure from base to summit, is divisible into two parts—a basal portion or pedestal 500 yards in circumference at its base and 100 feet high, and a column surmounting it, sixty-seven feet high and eighty yards in circumference at its base. The whole, with the exception of the few feet of more indurated rock on its summit, consists of a yellow and white

friable sandstone slightly tinged yellowish-red externally by hydrated ferric oxide. The presence of this layer of indurated rock explains the fact that the isolated Cretaceous table-topped hills have usually the form of truncated cones, the topmost stratum generally presenting a vertical edge for its whole thickness, while the slope of the portion of the hill occupied by the underlying softer strata varies from 32° to 40° from the horizontal.

(4) Ayers Rock and Mount Olga.

In addition to the foregoing mountain ranges there are some isolated mountains within the area examined that require a brief description. Rising like an enormous water-worn boulder, half buried in the surrounding sea of sandhills, is that remarkable isolated monolith known as Ayers Rock. It is situated about thirty-two miles S.S.W. of Lake Amadeus. The summit of this monarch of the desert can be seen from a distance of more than forty miles. At a nearer view its smooth, bold, flattened, dome-like outline stands out clear and distinct. This interesting relic of an ancient geological formation has puzzled explorers in no small degree. It rises to an elevation of about 1100 feet above the surrounding plains, and about 2500 feet above sea level. The sides of the rock, which has a circumference at its base of nearly five miles, are very steep, almost vertical in places and practically inaccessible, although Mr. Gosse succeeded after great trouble in ascending it. The rock is quite bare, with the exception of a few fig-trees, which maintain a precarious footing in the few crevices on its bare sides.

The rock has been often mistaken for granite, to which it bears some superficial resemblance, both in its lithological aspect and in its mode of weathering. The original sedimentary character of it, however, is unmistakeable, numerous very small rounded pebbles of quartz and felspar being distinctly visible in hand specimens. Although once a sedimentary rock, it has been to some extent altered by metamorphic agencies, a small amount of mica, perhaps of secondary origin, having been formed. The rock is a very indurated, and to some extent altered, arkose sandstone, decidedly gritty in parts.

The sides of this rock ascend in places quite vertically for a distance of 500 to 600 feet, while some of the more sloping faces are marked by a series of terraced waterfalls rising one above the other. A peculiar netted appearance is to be seen on some of the faces, a good example being visible on the northern face. This is due to the irregular weathering of the rock, the softer spaces, which have disappeared, having been separated by small intersecting veins of a harder material,

perhaps due to segregation along certain lines, which now stand out as low reticulate ridges.

A noteworthy feature of the rock is the manner in which it peels off. Firstly, on a small scale, thin flat flakes an inch or two in diameter and from one-eighth to a quarter of an inch in thickness are seen to be separating from the rock in all directions, and along no definite plane or set of planes. Secondly, on a large scale there may be seen, sometimes leaning against the base of the rock, having slipped from a higher level, or lying round its base, immense blocks of rock which have peeled off from the mountain, the phenomenon resembling on a large scale the concentric weathering of many eruptive rocks. In one or two places large blocks can be seen detached sufficiently to allow the sunlight to pass between them and the main mass, but still not entirely separated. One of these measures 8′ × 5′ × 200′, while others which are leaning against the base of the rock measure 6′ × 5′ × 20′ and 12′ × 6′ × 60′. Caves, usually of a small size, occur both near the base and on the sides and slopes of the rock. Lastly, a ridging is observable, which probably indicates the direction of foliation planes, trending in a N.W. and S.E. direction.

Fifteen miles west of Ayers Rock is another remarkable mountain mass, the most prominent and elevated portion of which is called Mount Olga. This, with numerous other peaks which rise from a common base, forms an isolated mass surrounded by red sandhills. Mount Olga rises to an elevation of about 1500 feet above the plain, and over 3000 feet above sea level. It appears to be composed of a coarse conglomerate from top to bottom, which consists for the most part of pebbles of granite and other eruptive rocks. The southern face of this mass is about five miles in length, and its western extremity rises perpendicularly for nearly 1500 feet.

Mount Olga from a distance presents a most remarkable outline, the many rounded dome-like elevations reminding one of the features usually presented by granite ranges.

B.—RIVERS.

The country traversed by the Expedition between Oodnadatta and the McDonnell Ranges lies wholly within a region of internal drainage, divisible into two basins, the centre of the largest and most important being Lake Eyre, and that of the other being Lake Amadeus. The basins of Lakes Eyre and Amadeus will be described in detail later. We will in the meantime confine our attention

to that portion of the Lake Eyre Basin, which is drained by the Finke, one of the most important rivers of the interior of Australia.

The McDonnell Ranges and the eastern extension of the Hart Range may be said to divide the drainage of the interior into two areas, of which the southern, which forms part of the Lake Eyre Basin, contains the most important rivers. The Finke, with its large tributary, the Hugh, takes its rise on the southern slope of these ranges, and flows towards Lake Eyre in a general southerly to south-easterly direction. The majority of the small creeks, which issue from the northern slope, do not discharge their waters into any common basin, but each maintains an independent course for a longer or shorter distance from the ranges, to become sooner or later absorbed by the sandhills and loamy plains. These latter creeks, of which the Darwent, Dashwood, Charley, Six Mile, Muller, etc., are examples, leave the ranges and flow northwards over the surface of the elevated plain, which is known to the north of Alice Springs as Burt Plain.

They have dry sandy channels, the banks of which are lined with gums, which are numerous and of vigorous growth near the ranges. There are a few creeks of this character heading from the south-western extremity of George Gill Range, *e.g.* King and Laurie Creeks. The former of these flows southwards in the direction of Lake Amadeus, but the flow of the water at fifteen or twenty miles from its source is not strong enough to form a channel, with the result that the flood waters spreading out over wide "gum flats" become absorbed by the surrounding sandhills.

There are, in addition to the above-mentioned small creeks, two or three larger ones taking their rise on the north slope of the McDonnell and Hart Ranges near their eastern extremities, which after a short northerly course sweep round to the south and flow towards Lake Eyre. As an example of these may be mentioned the Hale, the Sandover, and the Plenty, the two last of which ultimately unite to form the Marshall or Hay River. Speaking generally, one may say that the drainage from the southern slope of the McDonnell Ranges and from those ranges lying immediately to the south is sooner or later collected into one main channel known as the Finke, which trends in a general south-easterly direction towards Lake Eyre.

(1) Finke Basin.

(a) Nature and Position of its Watershed.—The northern limit of the Finke Basin is to a great extent formed by the McDonnell Ranges, the line of water-

parting extending along the northern edge of these ranges. The water-parting does not, therefore, traverse what are now the most elevated points in the ranges, such as Mounts Gillen, Sonder, etc., but lies wholly to the north of the ridge containing these points. This fact probably indicates that the summit of the arch, which originally determined the line of water-parting, lay near the northern edge of the McDonnell Ranges.

The mean elevation of the northern watershed is nearly 3000 feet above sea level. The water-parting of the Finke Basin runs along the northern edge of the McDonnell Ranges westerly to about Mount Ziel. From this point a straight line to the north-western extremity of Gardiner Range would nearly represent the north-west boundary of the basin. The western line of water-parting extends from this latter point to George Gill Range, and thence E.S.E. along the southern face of Levi Range. From Levi Range the rest of the western watershed is not well known; it passes at all events through the eastern extremity of the Musgrave and Everard Ranges. The exact eastern limit of the basin is practically unknown.

(*b*) *Area of the Finke River Basin.*—The area of the Finke River Basin cannot be less than 80,000 square miles. The basin is roughly triangular in shape, with the apex situated at Lake Eyre and the base coincident with the northern water-parting. The northern portion of the basin is the most elevated, the drainage being to the south and south-east. The mean elevation of this northern portion cannot be less than from 2500 to 3000 feet above sea level. About half the way between the northern watershed and the apex of the basin the mean elevation is about 1000 feet, while at Lake Eyre itself is is a few feet below sea level. A rough calculation of the average elevation of the basin makes it at least 800 feet above sea level.

(2) The Finke River.

(*a*) *Tributaries of the Finke.*—On the north side of Finke Gorge, through which the Finke flows in its southerly course, this river is formed by the junction of two creeks. The eastern branch, known as Ormiston Creek, rises on the northern edge of the McDonnell Ranges, and bursts through the prominent quartzite ridge between Mounts Giles and Sonder. The western branch, the Davenport, which is the more important of the two, takes its rise two to three miles S.E. of Mount Ziel, and flows for a few miles to the south, where it is known as the Crawford. It then suddenly turns to the east and is known as the Davenport. Before, however, it junctions with Ormiston Creek it is joined by

several small creeks, notably Redbank and Rockybar Creeks, both of which take their rise in the northern portion of the McDonnell Ranges, and, going south, force their way through narrow gorges in these ranges. The Finke flows southwards from the junction of Ormiston Creek and the Davenport, and at twelve miles from that junction, measured in a direct line, it is joined on the west by Rudall Creek, which rises in the south-western extremity of the south McDonnell Range, about 132° E. longitude, and which flows almost due east to the Finke.

Bending more towards the east, the Finke flows past the Mission Station (Hermannsburg), entering the Krichauff Range one mile south of this point. After a meandering course of from ten to fifteen miles through this range in a general S.S.E. direction, it is joined on the east by an important tributary, known as Ellery Creek. This latter takes its rise on the northern edge of the McDonnell Ranges, about 132° 50′ E. longitude, and flowing S.S.W., forces a passage through two quartzite ridges on its way to join the Finke. On its exit from the Krichauff and James Ranges, the Finke is joined on the west by Ilpilla Creek, a small tributary having its source in the James Range.

From this point the general course of the river is S.E. and is extremely tortuous. When it reaches 24° 45′ S. latitude and 133° 22′ E. longitude it is joined on the west by a very important tributary, the Palmer. The Palmer takes its rise on the northern slope of the James Range, about 132° E. longitude and 23° 40′ S. latitude., and flows in a general S.E. direction through this range for sixty miles, when it is joined on the west by an equally important tributary, the Walker. This latter has its source in the north-western extremity of Gardiner Range, and flows with a general E.S.E. course. The united streams, known as the Palmer, flow in an E.S.E. direction to junction with the Finke, 100 miles from the point where the Walker junctioned with the Palmer.

Petermann Creek, of less importance than the above-mentioned tributaries, takes its rise in what is known as Petermann Pound, a plain nearly five miles in diameter encircled by a line of hills about 400 to 500 feet high. This semicircle of hills unites George Gill Range with a western extension of that portion of the James Range known as the Station Range. From the Petermann Pound, Petermann Creek flows about due east, and occupies a longitudinal valley between George Gill and Levi Ranges on the south and a portion of the James Range on the north. In its passage eastwards it is joined by numerous small creeks flowing from the ranges on each side, one of the largest being Trickett Creek, which takes its rise on the south-east face of George Gill Range, and flows N.E. The valley of

Trickett Creek separates George Gill Range from Levi Range, which would otherwise constitute one continuous range.

Petermann Creek, after a nearly easterly course of about forty-five miles, joins the Palmer at ten or twelve miles below the Walker junction. From the Petermann junction the Finke pursues a nearly E.S.E. course for sixty miles, when it is joined by a very important branch, the Hugh. This river has its source on the northern edge of the McDonnell Ranges, about twenty-five miles west of Alice Springs, and sweeping through the range at Brinkley Bluff flows in a general E.S.E. direction. The Finke is next joined on the west by the Lilla at a point thirty-two miles in a direct line S.S.E. from the Hugh junction. About thirty-six miles in a direct S.E. line from the last point another creek, the Goyder, joins the Finke on the west. Further south still, and to the east of Charlotte Waters, it is joined by the Coglin.

Below the junction of this creek the Finke has no defined channel, but spreads out over wide alluvial flats. Sixteen miles S.S.E. of Charlotte Waters the telegraph line crosses Adminga Creek, which runs easterly to the flats over which the Finke waters spread. Still further to the south the Alberga, which takes its rise in the eastern extremity of the Musgrave Range, after being joined on the north by a tributary, the Stevenson, and being then known as the Macumba, flows E.S.E. towards Lake Eyre. It is into the Macumba that part of the flood waters of the Finke flow on their way to Lake Eyre. The greater portion, however, disappears from the surface, and is absorbed by the vastly extensive sandhills and plains, which stretch round the north and east sides of Lake Eyre. In the above description of the Finke and such of its tributaries as occur in the area examined by the Expedition, no mention has been made of the Todd, an important stream which takes its rise on the northern edge of the McDonnell Ranges to the north of Alice Springs. It leaves these ranges at Heavitree Gap, and at first has for many miles an easterly course, after which it turns S.S.E. towards Lake Eyre. It is very probable, but this is not certainly known, that the Todd junctions with the Finke south of Charlotte Waters.

(*b*) *Length and Rate of Fall of Finke Channel.*—The total length of the Finke from its source in the McDonnell Ranges to Lake Eyre must be about 1000 miles, although the distance in a direct line is not greater than 500 miles. A few calculations have been made on the rate of fall of the channel of the Finke over different portions of its course. The difference in the altitudes above sea level of the channel of the Finke at Mount Sonder and at the Mission Station, a distance of fifty-four miles, is about 490 feet. These data give a rate of fall of about nine

feet per mile. Between the Mission Station and the junction of the Palmer with the Finke the rate of fall is five feet per mile, the difference in the altitude of the two places being 699 feet, and the distance between them 135 miles. Lastly, the difference in the altitudes of the Finke Channel at the Palmer junction and at Lake Eyre, a distance of 536 miles, is 980 feet, which gives a mean rate of fall of less than two feet per mile. Between Heavitree Gap (1713 feet above sea level) and Oodnadatta (397 feet above sea level), a total distance in a direct line of 357 miles, the fall of the slope of the surface averages about 3·7 feet per mile.

The above figures show, as might have been expected, that the rate of fall is at its maximum in the McDonnell Ranges, and at a minimum on the Cretaceous plains near Lake Eyre, between which places there is a gradual decrease in the rate of fall as we go from north to south.

(*c*) *Nature of the Course and Channel of the Finke.*—As one might expect, judging from the figures just given, the course of the Finke from the McDonnell Ranges to the southern slope of the James Range is not so sinuous as it is after it debouches upon the Cretaceous plains. On these plains its course becomes extremely meandering, the river making its way down the very gentle incline from these ranges to Lake Eyre only after performing numerous sweeping curves. The width of its channel varies considerably, being usually narrower and deeper in the ranges, but widening out as it leaves them. On emerging on to the plains it becomes flatter and shallower and dotted with gum trees, which are not confined to the banks only as in the ranges, but grow often in patches even in the middle of the channel.

(*d*) *Absence of Surface Running Water.*—The absolute dependence of the presence of running water in the bed of the Finke upon direct supplies of rain has its explanation in the following facts :—

(1) The basin of the Finke, although of great extent, is entirely confined, or nearly so, to an area over which the climatic conditions are the same.

(2) Rain falls usually only at certain seasons, there being long intervals of drought.

(3) There is an almost total absence of springs at the head of the Finke and its tributaries, and in the few instances of their occurrence the discharge is very small.

The influence of these three factors on the absence of surface running water is obvious. After the flood waters caused by a heavy downpour have subsided,

and during the long intervals of dry weather, surface running water is absent from the greater length of the channel, its appearance for short distances only at certain parts being due purely to local causes. The absence or paucity of springs is to be attributed to the absence of a sufficiently thick layer of soil on the mountain slopes to act as a reservoir by absorbing the rain water and giving it out gradually at lower levels in the form of springs. It is also due to the absence of joints in the Pre-Cambrian and their scarcity even in the Ordovician rocks. The rain waters are, therefore, not absorbed, but form torrents, and rush down the bare mountain slopes into the valleys. When the waters have reached the beds of the water-courses, their rapid absorption by the porous strata and the excessive amount of evaporation that is always taking place cause the almost total disappearance of surface water from the river channels.

(*e*) *Waterholes.*—At certain seasons of the year, should the fall of rain be sufficiently great, the supply of water in the channels of the rivers exceeds the amount that can be absorbed by their sandy beds, and this produces a flow of water down the channel. This is often spoken of locally as a flood, as the waters as a rule are not confined to the channel by the low river-banks, but spread out over the wide alluvial flats which border the main channel.

When rain ceases to fall the flow of water diminishes almost immediately in volume. This it continues to do until running water disappears from the surface over an ever-increasing length of its course. There are, however, for a month or two after a heavy rainfall portions of the channel over which running water may still be seen; but these gradually decrease in length until the channel assumes what may be termed its normal state. In this state the channel is occupied by long stretches of white sand devoid of surface water, separated at rare intervals by short lengths of the channel, where water may be seen flowing gently over a rocky bed. In the apparently waterless stretches, however, water may be obtained by sinking to depths varying with the nature of the bottom and the lapse of time since the last heavy fall of rain. The appearance of surface water at rare intervals in the bed of the river is due to the presence of "bars" of rock, which cross the channel at these places.

As the water in its downward progress cannot filter through these rocks as it does through the sand and gravel at other parts, it has to rise to the surface to pass over them. The change from the normal state of the channels to their next condition is a more gradual one. As the supply of water becomes less and less, the amount and rate of flow over the rocky bars gradually diminish, until finally the supply becomes too small to cause the water to rise over them at all.

When the river has reached this stage in its desiccation, the isolated and often widely-separated waterholes and rockholes become economically important features. The principal waterholes occurring in the beds of the rivers and creeks may be described under the three following headings :—

1. Rockholes confined to gaps and gorges.
2. Waterholes on the upper sides of bars of rock.
3. Waterholes not associated with rocky bars, but occurring in the rivers where the bed is impervious.

1. *Rockholes confined to Gaps and Gorges.*—These occur in the many gaps and gorges through which the rivers and creeks have forced their way in their southerly course from one longitudinal valley to the next. In the quartzite ridge, for instance, forming the southern boundary of the south McDonnell Ranges proper, there are many gaps, the beds of the rivers in these being partly occupied by pools of usually excellent water. Such waterholes occur in the Redbank, Finke and Ellery Creek Gorges, and in Simpson and Emily Gaps.

The great strength of the current of the water flowing through these gaps, due to the fact of the streams being confined within narrow bounds, sweeps all detritus out of them and erodes the river bed to a greater extent here than elsewhere, thus often producing deep rockpools which retain large quantities of water. Many of these rockholes, owing to their sheltered positions, are practically permanent.

2. *Waterholes on the Upper Sides of Bars of Rock.*—The second class of waterholes are those situated on the upper side of some rocky bars. If the flow of water over the portions of the river channels in which these occur is strong, then the eddy in front of the bar causes the removal of sand and gravel from this side, and leaves, as the water subsides, a depression filled with water. Unfortunately, however, at a later period a light rain often causes a flow of water just strong enough to carry sand, etc., into this hollow and thus obliterate it. For this and other reasons one cannot always depend upon getting water on the surface at these places, even though one may have seen on a former occasion a fine pool of water at the same place. A very good example of this class of waterholes occurs in the Finke near Henbury Cattle Station.

3. *Waterholes not Associated with Rocky Bars.*—The third class of waterholes owe their existence to their being situated over the portions of the river beds where fine silt or mud takes the place of porous sand and gravel, and thus prevents the

percolation of the water below the surface. When the flood-waters abate over these portions, there usually remain a string of waterholes occupying the depressions in the river bed. If rain does not fall for some time these one after another lose their water by evaporation and become dry. Only those which occupy the deepest and most sheltered depressions hold out for any length of time. Such waterholes prevail in the Cretaceous area as in the Stevenson, Macumba and Coglin Rivers, and form the chief sources of supply in the districts where they occur.

What a valuable provision of nature in reality are the sandy beds of the rivers! Through the sand and gravel the water creeps slowly down its course protected to a great extent from evaporation, and here it may generally be obtained by sinking; whereas if it had remained on the surface it would have been rapidly evaporated. Only in those places where ledges of rock cross the channel do the waters appear at the surface, and then usually for a short distance only, disappearing again in the sand on the other side of the rocky bars.

Seldom do the flood-waters of the Finke and Macumba flow over the surface to Lake Eyre; for the lacustrine delta of these rivers, consisting for the greater part of deposits of sand and loam which have been accumulating during the Late-Tertiary and Post-Tertiary epochs absorb the immense body of water brought down by these rivers.

(*f*) *Rainfall in its Relation to Surface Water.*—The rainfall throughout the area of the Finke Basin is somewhat variable, ranging from an average of less than five inches per year in the central and southern portions to ten or twelve inches over much of the mountainous country in the northern part of the basin. The mean annual rainfall throughout the basin cannot be more than six to seven inches.

A great part of the moisture that falls as rain throughout this area is lost by evaporation. From claypans and all shallow depressions which expose large surfaces to the desiccating agents, the water disappears in two or three months after a fall of rain. From the waterholes, too, during the dry season the water disappears at an alarming rate. Waterholes which have been examined by one explorer during a good season, and declared to be permanent, have, when examined later by a second explorer in a rather dry season, been often found to be dry or nearly so. Explorers have indeed been rather too hasty in forming conclusions as to the permanency of waterholes, which, visited perhaps during a good season, contained a good supply of water, but which had in reality no element of permanency. In the great majority of cases they are not fed by springs nor situated in places sufficiently sheltered to give practical permanency to them.

Besides the great quantity of water directly evaporated, some of it goes to supply the wants of the Gums which line the banks of the creeks. In times of heavy flood some of the water may reach Lake Eyre along the channel of the Macumba, while a large portion filters gradually down towards Lake Eyre through the bed of the creek at a moderate depth from the surface. Lastly, an important portion of the rainfall percolates through the outcrops of the porous strata of Cretaceous age, travels downwards towards Lake Eyre, and forms the supply from which the artesian water is derived. Some of this water reaches the surface again in several localities by natural outlets, and issues from the mouths of mound springs. Some of the water probably percolates through the sand and gravel of the river beds, and in this way reaches the water-bearing strata of the artesian basin.

C.—GORGES AND GAPS.

The next features to be described are the gorges and gaps, which are rather numerous in the ranges in the northern portion of the region under consideration, and through which many of the rivers flow on their ways southwards towards Lake Eyre. These features are in the form of narrow rocky passes with walls usually of quartzite, but sometimes of sandstone, rising almost vertically to heights varying from 200 to 700 or 800 feet above the valleys. Their length varies exceedingly, while in width they range from a few feet to forty or fifty yards. Many of the rivers after flowing equatorially for some distance along the longitudinal valleys turn abruptly to the south, and cross the ranges through these gaps.

In most of the gaps are beautiful pools of clear fresh water, in which large numbers of fish live, belonging, however, to a few species only. It has been thought that these gaps occupy the sites of faults in the strata, but it appears to us to be quite unnecessary to call in the aid of such dislocations to account for their origin. The origin of the majority of the gaps is probably due to the erosion of the river beds in the positions of the present gaps keeping pace with the upheaval and folding of the strata in those places. By thus lowering their channels the rivers have maintained their original positions. In a few cases, however, the gorges may owe their existence directly to faults, the water readily eroding a passage for itself along the fault planes and their associated cracks.

D.—LAKES.

The interior district of Australia, *i.e.*, the portion which has an internal drainage, comprises an area of nearly a million and a half square miles, and is,

therefore, seven times as large as the Great Basin of North America. It will thus be readily understood that the lakes, which form the centres of the several drainage basins, are physical features of the greatest interest and importance. Surrounding the area of internal drainage is a strip of country stretching inland from the coast for varying distances, throughout which the rivers carry the surface water to the ocean.

Only two lakes occur in the region considered in this paper, viz., Lakes Eyre and Amadeus, each of which forms the centre of one of the divisions of the internal basin. Both of these are fast passing into the state of dry basins. This is due in the first place to the aridity of the climate throughout the region occupied by them, from which results an almost total absence of superficial flow of water into the lakes, *especially Lake Amadeus;* and in the second place it is due to the accumulation in the lakes of sand, etc., transported thither by running water or wind. These statements apply in a special manner to Lake Amadeus, the absence of surface water near its western extremity at any rate being specially noticed by Mr. Tietkens.

From the sandhills bordering the lake near Gosse's Crossing, *i.e.*, towards its eastern extremity, we could make out no water on its surface. There the dry bed of the lake was crossed without trouble *en route* to Ayers Rock and Mount Olga.

Of these two lakes Eyre is the larger and the more important, and will be considered first.

Lake Eyre.

Lake Eyre receives the drainage from the McDonnell Ranges, and the ranges lying immediately to the south of them, together with the drainage from a great part of west and south-west Queensland. Its basin includes those of all the rivers that drain into it, and having no outlet it is entirely encircled by a line of water-parting. The drainage throughout the basin is to the S.E., S., and S.W., Lake Eyre itself being situated close to the southern border of the basin.

The Lake Eyre Basin occupies the eastern half of South Australia between the northern termination of Flinders Range and the McDonnell Ranges, and the greater portion of west and south-west Queensland from the Great Dividing Range westwards. The rivers which drain this enormous area are taken in order from west to east, the Neales, Macumba, Finke, Todd, Hale, Sandover, Plenty, Mulligan, Diamentina, and Cooper or Barcoo.

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The western boundary of the Lake Eyre Basin is formed by the Cretaceous plains flanking on the east the Everard Range, in which the Neales River takes its rise, by the eastern extremity of the Musgrave Range, from which the Alberga heads, and by the western extremities of the George Gill and Gardiner Ranges, where some of the large tributaries of the Finke have their sources. The northern boundary is formed by the McDonnell and Hart Ranges. The north-eastern and the eastern are formed by the Selwyn, McKinlay, and the Great Dividing Ranges, in which the sources of the Mulligan, Diamentina, and Barcoo (Cooper's Creek) are situated. Lastly, the southern boundary is for the most part formed by the northern slope of the Flinders Range, from which short narrow creeks flow northwards to Lake Eyre.

Form, Area, etc.—The general form of the basin is roughly quadrilateral, with one angle situated on the northern slope of Flinders Range, to the south of Lake Eyre south. Another of the angles coincides with the western extremity of the McDonnell Ranges about Mount Ziel. A third lies near the head of the Mulligan and the last is situated about the source of the Barcoo River. The total area of the basin cannot be less than 500,000 square miles, the greatest breadth, lying along the 24th parallel, is about 900 miles, and the greatest length, occurring about the 137th meridian of E. longitude, is about 750 miles.

Lake Eyre itself, including Lake Eyre south, lies within the 137th and the 138th meridians of E. longitude and between 27° 50′ and 29° 29′ S. latitude, and occupies an area of about 5000 square miles. It is situated almost at the very southern extremity of the basin, the south edge of Lake Eyre south being only a few miles north of the northern extremity of Flinders Range. The margin of Lake Eyre has been calculated to be thirty-nine feet below sea level.

Lake Amadeus.

The Lake Amadeus Basin is not well known, but it appears to be of small extent as compared with that of Lake Eyre. It comprises in all probability an area of between 20,000 and 30,000 square miles. The northern boundary of the basin extends probably from the western end of George Gill Range to Watson Range, and thence along the north of the 24th parallel to about the Western Australian border. The southern limit of the basin lies possibly along the Rawlinson and Petermann Ranges, while its eastern and western boundaries are apparently unknown.

Lake Amadeus itself was discovered and named by Mr. Ernest Giles in 1872, when it proved an insuperable obstacle to him in his westward course towards Western Australia. In 1873 it was crossed by Mr. Gosse at a narrow neck near its eastern extremity; but in the next year Mr. Giles was again forced to retrace his steps, the bed of the lake, where examined by him, being found to be so boggy as to be impassable. In 1889 Mr. Tietkens examined the western portion of the lake, and was consequently able to define approximately its true outline, which had previously been extremely hypothetical. His examination of the lake resulted in the shortening of its length, as shown on the maps up to that time, by more than 100 miles.

Its extreme western portion, which was previously supposed to be situated about 128° 10′ in Western Australia, and to be about twenty to thirty miles wide, is now known to be situated in South Australia, about 130° 18′, and to be only from two to three miles wide.

According to Mr. Tietkens, its extreme length is about ninety-two miles, while its width varies from two to fifteen miles, the maximum width of fifteen miles occurring about the 131st meridian. At the narrow neck, however, where we crossed, it is not more than three-quarters of a mile wide.

The area of the lake is approximately 700 square miles, and its altitude above sea level must be more than 1000 feet.

One set of calculations of its elevation were based on Mr. Winnecke's figures for the altitudes of the camps at Bagot Creek and Reedy Hole, and on the differences between the barometrical readings at those places and at Lake Amadeus; while another set were based on the barometrical readings given by Mr. Tietkens in his Journal, etc.

As far as known, Lake Amadeus receives the drainage of a few small creeks only, as no rivers of any importance have up to the present time been discovered within the area of its basin. The view of the lake gained from the neighbouring sandhills is a very remarkable one. Stretching away to the east and west as far as the eye could discern was a dazzling, white, flat expanse, on whose surface no water could be seen, but in its place a coating of a white saline material, which on analysis proved to be composed almost entirely of common salt, with a small amount of sulphate of lime (gypsum). On closer examination the saline crust was found not to exceed a quarter to half an inch in thickness, under which was a red argillaceous sand passing down into similar material of a grey colour. The surface of the lake was found to be tolerably firm, the horses only sinking to the depth of

a few inches. On each side of the lake the sandhills rise to a height of fifty feet, and have a nearly east and west trend.

E.—CLAYPANS.

After the description of the lakes it is necessary to say a few words about those miniature lacustrine features known as "claypans." They are usually in the form of flat shallow depressions, often nearly circular, but in the majority of cases of irregular outline, and usually devoid of vegetation. They are generally surrounded by loamy plains or sandhills, and while they are more frequently met with throughout the Cretaceous area, they are still not uncommonly found on the plains and in the valleys of the ranges within the Ordovician area. Mr. Streich suggests that claypans owe their existence* to an ascent of subterranean water at the junction between the "sedimentary and the metamorphic formations," as he found them numerous in the neighbourhood of the junction line. We, however, observed no such relation, and give below our explanation of their formation.

Claypans vary in diameter from a few feet up to as much as three-quarters of a mile, a common size being from fifty to one hundred yards. They are exceedingly shallow, the depth of the bottom below the general level of the surrounding sandhills or plains is seldom greater than five feet, and usually much less, being in the majority of cases not more than two to three feet. In some cases the edge of the depression is ill-defined, the plain merging almost imperceptibly into the claypan, and the only indication of the circumferential limits is the ring marking the edge of the deposit of fine silt which covers the bottom and sides of the claypan. In other cases the sandhills come to the very edge, and form a well-defined rim to it. The area drained by them is limited to a very narrow peripheral belt. As a general rule water does not remain in them very long; some of the best hold water for three or four months, but in the great majority of cases, especially of the smaller ones, the water disappears from them at the end of a month or two. There are exceptional instances, however, of which Conlon Lagoon is an example, in which water would remain for very much longer periods.

The water of the claypans has generally a reddish-yellow colour, due to the presence of a quantity of very fine mud of that colour held in suspension, which on evaporation of the water is deposited on the bottom of the claypan as a fine silt with a peculiar glazed surface, due perhaps to the extreme fineness of the last portion of the sediment deposited. On drying, this mud loses water and splits in

* Trans. Roy. Soc. of South Australia, vol. xvi., part ii., p. 90.

all directions, cracks as much as a quarter to half an inch wide making their appearance and separating the more or less rectangular masses from each other.

The following explanation of the method of their formation has suggested itself to us. They naturally occur only where the country is flat, *i.e.*, where the slope of the ground is not decided enough in any particular direction to cause the surface water to flow in that direction. There is therefore a tendency for the water to lie on the surface, or rather to be gathered into slight depressions, which are sure to exist even on otherwise almost level surfaces. At first the water that was gathered into these slight depressions would almost immediately percolate the porous strata, but in doing so it would leave behind a deposit of silt. This would happen with every subsequent heavy fall of rain, until the silt suspended in the water and carried into the depression and deposited there was in sufficient quantity to prevent further percolation.

The claypan has now become established and will retain water for a longer or shorter period, and as there is now very little percolation through the bottom there will be no further settling of the floor as there may have been in the early stages. The depth of the claypan in many cases will, however, be increased by the growth of the rim by the deposition at the water's edge of the fine particles of sand, etc., driven along the surface of the ground by the wind. In this manner the rim may be added to from time to time, and the holding capacity of the claypan thereby increased.

The largest example of a claypan seen during the Expedition is one that occurs a few miles to the south of Heavitree Gap, and known locally as Conlon Lagoon. In its greatest dimensions it is a quarter of a mile wide and three-quarters of a mile long. The depth of the bottom of the lagoon below the surrounding country does not exceed four or five feet, and as there was at the time it was visited not more than three feet of water in it, it was already in process of drying up. Where dry the bottom was seen to be formed of a clayey sand. Conlon Lagoon lies between two ranges trending east and west, the drainage from which finds its way into the lagoon. There is, however, no indication of an outflow eastwards to the Todd (the only possible direction), the lagoon and the ranges on the north and south forming a miniature internal drainage system of their own.

F.—STONY PLAINS.

The whole of the area from the northern extremity of Flinders Range northwards to within a few miles of Mount Burrell Cattle Station on the Hugh River,

and for many miles in an easterly and westerly direction, may be said to be occupied by rocks of Cretaceous age, covered over large areas by Post-Tertiary deposits and over very limited areas by Pliocene beds of lacustrine origin. The upper strata of the Cretaceous system have been removed by denudation over extensive areas, the remaining portions being in the form of more or less isolated table-topped hills dotted about throughout the whole area. The materials set free by this denudation have gone to form the superficial accumulations known as "gibber" or "stony plains," loamy plains, and to a large extent also the sandhills.

"Stony plains" is the name given to those portions of the Cretaceous area over whose surface are strewn "gibbers," *i.e.*, rounded or subangular fragments of silicified sandstone or grit known as "desert sandstone." The desert sandstone is extremely hard and weather-resisting, and has a somewhat sub-conchoidal fracture. With such properties it is not surprising to find fragments of it covering much of the country from which the sandstone has been denuded.

The uniform distribution of the gibbers, which is a very characteristic feature of this class of country, is due to the fact that the fragments derived from the layer of "desert sandstone" which extended over this area, now strewn with gibbers, have not undergone redistribution to any large degree. In a flat district like this the surface water has not been able to sweep them into water-courses. The removal of the argillaceous sand by the wind and rain has permitted the gibbers to settle down, until in many places they present a flat surface resembling an artificial pavement. The outer surface of the gibbers is of a dull red colour, due to the presence of a thin film of oxide of iron coating them. They also present a glazed sub-angular or pseudo-waterworn appearance, produced by the polishing action of the sand grains as they are driven along the surface of the ground by the wind.

The stony plains gradually merge into loamy plains, which possibly occupy the sites of areas of the Upper Cretaceous, which were devoid of the "desert sandstone" capping.

On either sides of the banks of many of the rivers, especially along their serpentine courses over the plains, are extensive alluvial plains. During floods the channels are too flat and shallow to carry off the immense body of water that occasionally comes down them, and the water spreads out on either side, sometimes for miles. The "box flats," which are met with on the sides of the Finke Channel, are flood plains, on which *Eucalyptus microtheca* flourishes in large numbers.

G.—SANDHILLS.

The last features of importance are the sandhills, which occupy the surface over immense areas of the interior. These are ridges of usually a red argillaceous sand, having in many localities an approximately parallel arrangement, and therefore with a constant trend usually N.E and S.W., due to the prevalence of S.E. winds, but elsewhere occurring quite irregularly. The trend of the sandhills is to a great degree dependent upon the direction of the prevailing wind, being almost at right angles to this. Separating the ridges are the corresponding diminutive valleys, the floor of which is usually of a much more clayey character than the material of the sandhills. They have one steep fall inclined at an angle of about 30° and situated on the side opposite to the quarter from which the wind blows, the other side having a gentler slope.

The sandhills rise to very varying heights, thirty or forty feet being a very common height, while in some cases they reach seventy feet, or even in some extreme cases 100 feet above the level of intervening flats. The highest sandhills were crossed during the trip from George Gill Range to Ayers Rock, where also the greatest development of them was seen. The surface of almost the whole of this strip of country is occupied by sandhills, which are clothed over very large areas with "porcupine grass" (*Triodia*).

GENERAL GEOLOGY.

By PROFESSOR RALPH TATE and J. A. WATT, B.Sc.

(WITH PLATES 1 AND 2).

The geological features of that portion of Central Australia examined by us, embracing the country lying between Oodnadatta on the south and the ranges on the north, will be described under a number of headings. Under each of these, bearing the names of the geological systems to which the different series of rocks are assigned, a summary of the conclusions of previous observers and an account of the general geological features, the extent, thickness, mineralogical composition, petrological characters, and fossiliferous contents of the rock will be given. Detailed descriptions of the fossils and of the microscopical characters of the more important rocks form the subjects of separate papers.

I.—Previous Records and References to the Literature of the Region.

I.—WATERHOUSE, F. G., "Features of Country on Stuart's Track across Australia," Parl. Paper, S. Aust., No. 125, 1863. The author was naturalist to Stuart's Transcontinental Expedition, and in his report makes incidental references to geological features. He divides the country into:—

(1) The spring and salt-bush country extending from the Goolong Springs to a little north of Hanson's Gap (lat. 27°, 18′, 23″). The springs are stated to be of volcanic origin (pp. 1, 3, 4), and as proceeding from volcanic lava and extinct cones. Reference is made to the discovery of the remains of *Diprotodon australis* at Hergott Springs (p. 2), and of fossil shells in an argillaceous rock, attributed to the Tertiary age, at the Gregory and Welcome Springs (p. 2). [This formation is now known to belong to the Rolling Downs system, and the mussel-shells alluded to are *Modiola inflata*, Moore.]

(2) This division extends to the southern side of Newcastle Water (lat. 17°, 36′, 29″), and is described as somewhat sandy and occasionally stony and loamy soil, with some considerable range of hills (p. 5). A geological section on the banks of Finke River at Polly Springs, near Engoordina, is described in the

following terms:—"At the bottom an argillaceous schist, above many horizontal strata of a soft argillaceous rock, occasionally interstratified with a free sandstone of various hues; at the top was a stratum, not very thick, of a peculiar siliceous rock of a drab colour; it breaks with a conchoidal fracture and looks like very hard baked earthenware" (p. 5).

[The basal formation indicates an inlier of Pre-Cambrian age; the intermediate argillaceous series represents the type of the Upper Cretaceous which prevails on the northern confines of the basin; the uppermost formation is of the usual, desert sandstone, type.] The James and Waterhouse Ranges are constituted of a dark, hard ferruginous sandstone (p. 5). [The characteristic rock of the Larapintine Series (Ordovician)]. In the gorge of the Hugh River in McDonnell Range "the rock is a variety of gneiss of a very laminated nature." [This description is more apt than that of Stuart].

II.—Stuart, John Macdougall, "Journal of Explorations in 1858-63," London, 1864. The first geographical exploration of the region under review was by Stuart on three separate occasions embraced in the years 1858-1862. He describes the axis of the McDonnell Range, particularly at Brinkley Bluff, as consisting of granite.

III.—Gosse, W. C., "Exploration in 1873," Parl. Paper, S. Aust., No. 48, 1874. [The determinations of some of the rocks referred to by Gosse are based upon the examination of the original specimens in the Museum of the School of Mines at Adelaide]. The author describes the rock-structure of Mount Liebig, the most westerly point of the McDonnell Range, as composed of basalt, gneiss, and sandstone; strike E., dip 14° S.; the rock (-face) perpendicular for 400 and 500 feet on south side. [The original specimens are gneiss, hornblende-schist, and quartzite]. A granite ridge between Mounts Liebig and Udor has a strike E. x S., dip 4° S. [A rock labelled Mount Udor is an example of Ordovician quartzite]. The ridge of the West Bluff Hills is composed of gneiss; strike S.E. x E., dip 81° S. Mount Palmer is composed of granite, gneiss, sandstone and puddingstone; strike W., dip 15° north. [Rock specimens labelled King's Creek, George Gill's Range, are limonite and a fine-grained compact sandstone of Ordovician age]. "Ayers Rock is a high mass of granite 1100 feet above the surrounding country." [A specimen labelled Ayers Rock is a small rolled fragment of epidote-hornblende.]

IV.—Giles, Ernest, "Geographic Travels in Central Australia from 1872-1874," Melbourne, 1875. The chief geological records by this explorer, which

the authors have had the opportunity of personal investigation, are :—"Chambers' Pillar is composed of a loose white sandstone" (p. 6). "Johnston's Ranges had the very red appearance of red sandstone, and had a series of ancient water-marks along their sides" (p. 7). "The ranges by the Finke River, two miles north of McMinn's Creek, are composed of red sandstone, stony and precipitous, 800 feet above the plain" (p. 11). "McDonnell Range is formed of three separate lines of hills, running east and west, the most northern the highest, fully 4000 feet above sea level; the other two lines may be called only foot-hills, the most southern and lowest is formed of sandstone, the middle tier is basalt, and I believe the main chain is of basalt also; the southern flank I found to be composed of pudding-stone" (p. 17). "Gosse Range is composed entirely of red and white sandstone" (p. 19). "The higher mountain beyond (Mount Tate of Winnecke) was girt around by a solid wall of basalt, fifty or sixty feet in height, from the top of which the summit rose" (p. 22). Sandstones occur at Glen Edith (p. 43); the George Gill's Range is composed of enormous masses of red sandstone (p. 58). Mount Olga is formed of several vast and solid rounded blocks of bare red-coloured stone of a kind of conglomerate (p. 95).

V.—Smyth, R. Brough, "First Sketch of a Geological Map of Australia," Melbourne, 1875. The James and Gardiner Ranges and the McDonnell Range west of the Finke River are coloured as granite within an area of metamorphic rock, which extends west to Alice Springs. Metamorphic rock in a small area is shown resting on the west bank of the Finke River, extending from Charlotte Water to the Lilla Creek. The rest of the Larapintine and southward to the Macumba River is represented as Tertiary.

VI.—Chewings, C., published in 1886 a sketch-plan of the Larapintine area as the outcome of personal survey, on which is represented, by shading, basalt, sandstone, and granite :—"The McDonnell Ranges are composed chiefly of basalt; though sandstone and granite are plentiful, the basalt formation forms the backbone, frequently rising 2000 odd feet above the plain." [Basalt is indicated as forming the higher levels of the escarpment of the George Gill, Levi, and Middle Ranges and elsewhere, the rest of the rocky country being represented as composed of sandstone.]

VII.—Department of Mines, Victoria, "Geological Map of Australia," Melbourne, 1887.—The metamorphic area on the west bank of the Finke River, between Charlotte Waters and Lilla Creek, of the former map is herein represented as Lower Palæozoic; the east side is coloured as Cretaceous, and the area is

extended northward to include Chandler's Range. The Levi and George Gill Ranges are indicated as Tertiary, whilst the main portion of the Larapintine is represented as granite and Newer Volcanic, except a small patch around Alice Springs which is coloured as metamorphic.

Up to this date the work done has little claim to serious attention, as it consists almost solely of locality-records of a few kinds of rock-masses; no attempt had yet been made to indicate their stratigraphical relationships, except in the sole instance by Waterhouse, respecting the section at Polly Springs. Some excuse may therefore be found for the imperfection of the two geological maps issued by the Victorian Government, the compilers of which had no other data before them than such bare records as we have sketched herein. The information had to be taken for what it was worth or wholly rejected; hence the great blot of volcanic colouring on the later map, which error is traceable to Giles, and was repeated and enlarged upon by Chewings. Their basalts are the thick quartzite bands in the Larapintine Series, and perhaps also those of the Pre-Cambrian.

VII.—East, J. J., "On the Geological Structure and Physical Features of Central Australia," Trans. Roy. Soc. S. Aust., vol. xii., pp. 31–53, pl. iii., 1889 (Read 2nd April).—Being observations made along the Overland Telegraph Line from Lake Eyre to the McDonnell Range, and deals with the south and north-east parts of the country traversed by us.

Topographical Features.—(1) "The Great Austral Plain" embraces the low level country about Lake Eyre and the table-topped hills and small table-lands which arise from it—a vast region of inconsiderable elevation. Sterile patches covered with glazed subangular stones are herein called "gibbers." (2) "The Terraces" embrace the parallel ranges of low altitude, separated by broad valleys or plains, commencing near the junction of the Hugh and Finke Rivers. [The term "terraces" is inapt]. (3) "The Great Central Plateau," the southern boundary of which is the McDonnell Range, whose furrowed southern face developes the system of narrow ridges collectively known as the McDonnell Ranges. [This description, as also the section, pl. iii., fig. 6, is misleading, as the general altitude of Burt Plain, to the north, is the same as that of the river-valleys in the McDonnell Range].

Geological Structure.—(1) Outliers of the Flinders Range from Finnis Springs to Mount Dutton are classed as Archaean [Our observations incline to the opinion that, though the Peake Range is doubtlessly Pre-Cambrian, yet the fissile limestone and associated strata from tho Neales River to Mount Dutton belongs

to the Cambrian]. (2) The beds of the table-land of the Great Austral Plain in the vicinity of Dalhousie Springs are described as consisting of a great argillaceous series crowned by porcelainised sandstone; they are considered "to be Mesozoic (and probably Cretaceous)." The porcelainisation of some of these strata is considered to be due to submergence in silicated waters which are wholly evaporated (p. 51); and it is noted that "the obsidian bombs are most numerous among the portions of the plain whose surface is strewn with chalcedony and ironstone nodules" (p. 53). The foundation rocks of "the Terraces" consist of fissile sandstones, argillaceous and siliceous limestones, as in Mount Charlotte ridge, and appear in gentle undulations, which become more and more sharply curved on approaching the McDonnell Range (pp. 46, 51). The central plateau consists of impure limestone and an underlying red quartzite, which forms the south edge of the central plateau and rests on gneiss and granite intersected by diorites—the whole, from Lake Eyre to the Burt Plain, representing a conformable series (p. 47), though a doubt is expressed with regard to the rocks of the McDonnell Range, which, on the ground of their degree of metamorphism, may perhaps be considered Archæan (p. 51). [(3) Nevertheless, the schistose rocks at Polly Springs are compared with the primary rocks of Denison Range]. (4) Describes gravels containing large boulders of granite and schist on the north flank of Cunningham Gap, and suggests their derivation from "a bar of primary rocks," of which those at Polly Springs may be a remnant (p. 44).

IX.—Brown, Henry Y. L., "Report on a Journey from Adelaide to Hale River," Parl. Paper, S.A., No. 24, 1889, with Map and Sketch Section. "From Mount Dutton northward to the vicinity of Mount Burrell the whole country is occupied by the Cretaceous and Tertiary formation." Extinct mound-springs are stated to occur at Dalhousie Head Station. In the vicinity of Mount Burrell, commencing three miles south from it, are crystalline limestones with flinty veins, quartzite slaty sandstone and cleaved slates; these are considered Primary (probably Silurian). Overlying these, first seen at and northward of Ooraminna Well, are brown and white sandstones, which are classed by the author as Devonian (?) or Silurian. The red quartzites and overlying beds which form the southern barrier of the McDonnell Ranges are included with the granitic and metamorphic rocks which compose the main ranges under the head of Azoic.

X.—Brown, Henry Y. L., "Report of Geological Examination of Country in Neighbourhood of Alice Springs," Parl. Paper, S.A., No. 189, 1890. The fundamental rocks of the McDonnell Ranges are various metamorphic rocks with eruptive dykes of diorite, pegmatite and coarse granite. Resting unconformably

upon these are quartzites (sometimes conglomeratic), dolomitic limestone, and occasionally clay-slates, and are classed as "Cambrian (?)." In the main valleys of the ranges are flat-topped hills of quartzite, conglomerate, ironstone, and ferruginous sandstone; these beds belong to the Secondary or Tertiary age.

XI.—CHEWINGS, CHARLES, "Geological Notes on the Upper Finke Basin," Trans. Roy. Soc. S.A., vol. xiv., pp. 247–255, pl. x., 1891. The stratigraphical sequence as established by the author is as follows:—

PRE-SILURIAN.—Developed in the McDonnell Ranges. [Certain limestones and shales are included, which the writers refer to the next series.]

SILURIAN.—Comprising the "McDonnell Ranges south." This assigned position is based on the fossil evidence as interpreted by Prof. Tate (p. 255). [Herein are included the Post-Ordovician conglomerates of the present writers.]

DEVONIAN.—Rocks of this age occupy, according to the author, the synclinal folds of the Silurian quartzites; to which also belongs the Ooraminna sandstone. [These we fail to separate stratigraphically and structurally from the Ordovician.]

MESOZOIC (?)—To this period belong a coarse sandstone formation, forming flat-topped hills in the heart of the McDonnell Range. [The development at Glen Helen Station referred to by the author consists of the residue of the waste of the gneissic and granitic rocks, and offers no analogy to the Cretaceous rocks on the southern borders of the Primary as suggested by Brown (x., p. 2).]

CRETACEOUS.—A limestone rubble with flints and gypsum resting unconformably on the supposed earlier Mesozoic rocks, at the junction of the Palmer and Walker Creeks, is in the opinion of the writers a recent travertine.

TERTIARY.—"The cone-shaped hills composed of clay-grit, horizontally bedded," as seen by us at the extreme of Petermann Creek, on the Walker, and Vale of Tempe, are outliers of low-dipping Ordovician sandstones.

XII.—BROWN, HENRY Y. L., "Report on Leigh Creek Coalfield," Parl. Paper, No. 158, 1891, p. 12, states that "lying unconformably on the crystalline metamorphic, gneissis, and granitic archaean rocks of the McDonnell Ranges there are two other rock-systems unconformable to each other. The lower of these consists of quartzite, quartzite conglomerate, dolomitic limestones, etc., striking E. and W. . . . in descending the Finke they appear at intervals as highly-inclined beds, the outcropping edges of synclinal troughs in which rest the upper system. [These are referred to Cambrian.] The upper system consists of sandstone quartzite,

shale, and thin bands of limestone, also striking E. and W. . . The George Gill and James Ranges are composed of these rocks. It is from these that Silurian fossils were obtained."

XIII.—Tietkens, W. H., "Journal of the Central Australian Exploring Expedition," Adelaide, 1892. In 1891 Mr. Tietkens, in command of a prospecting party, started from Alice Springs, skirting the north front of the McDonnell Range to Mount Heuglin, thence to Mount Sonder and Glen Edith, and westward beyond the West Australian boundary; on his return route he examined Mount Olga and Ayers Rock. A catalogue of the rock-specimens collected by Tietkens is furnished by Mr. H. Y. L. Brown (Appendix, pp. 82–84), who also, by sketch-sections, shows the stratigraphical structure of the McDonnell Range west of Mount Sonder, and of Mount Olga and Ayers Rock. Mount Sonder to Mereenie Bluff, Mount Olga and Ayers Rock are coloured to represent "Metamorphic metal-bearing rocks" overlying granite. The quartose sandstone at Glen Edith is referred to "Palæozoic (Devonian ?)."

XIV.—Brown, Henry Y. L., "Further Geological Examination of Leigh's Creek and Hergott Districts," Parl. Paper, S.A., No. 23, 1892. The Government Geologist made "a brief and rapid examination of the Finke River region in September, 1890," and herein, under the title of "General Geology on the Finke River," p. 7, he amends his previous outline description which is illustrated by an ideal section from the McDonnell Range to Charlotte Waters.

The fundamental rocks are classed as Archæan; the quartzites, dolomites, limestones, sandstone and slate which crop-out in anticlinal arches on which the succeeding formation rests apparently unconformably are classed as Cambrian. The Post-Ordovician conglomerates at the Finke Gorge are here included. The author records that the metamorphic granitic rocks dip under quartzite at Mount Sonder and in a southerly direction are succeeded by highly inclined dolomites, etc.

Lower Silurian. According to this author, the rocks of this age commence in the range bounding the Missionary Plain on the south, and extend south to Henbury and Ooraminna, the only distinction from the foregoing is "a less disturbed rock-formation."

XV.—Chewings, Charles, "Notes on the Sedimentary Rocks in the McDonnell and James Ranges," Trans. Roy. Soc. S.A., vol. xviii., pp. 197–199, 1894. This is, in part, a correction of previously published opinions (xi.) and a criticism of Mr. Brown's classification (xii. and xiv.); his grouping is as follows :—

FOUNDATION ROCKS, previously called Pre-Silurian. GLEN HELEN SERIES (Cambrian and Pre-Cambrian?) is introduced by a quartzite, overlain by crystalline limestones, dolomites, clay-slate, etc.; rising through the eroded Lower Silurian anticlines. MAREENO BLUFF SERIES (Lower Silurian part) embraces the fossiliferous limestones and associated sandstone and quartzites. WALKER CREEK SERIES (Devonian?); as previously, the author regards these beds as unconformable with the Ordivician, whereas we recognise them as only the more gently undulating Larapintine sandstones (Ordovician).

II.—Pre-Cambrian.

(*a*) *Introduction.*

Much attention has of late years been paid by geologists in Great Britain, on the Continent of Europe, and in North America to the study of the important but very complex series of rocks variously known as Archæan, Azoic, Pre-Cambrian, etc., which underlie unconformably the base of the *Olenellus*-zone of the Cambrian system wherever it is developed. The result of this laborious work has been the establishment of our knowledge of the origin, tectonic structures, and geological relations of the different members of this heterogeneous division of rocks, and their relation to the overlying Palæozoic fossiliferous strata on a sounder basis. Unfortunately very little work of a similar nature has been done in Australia, where the extensive and easily-accessible areas of Pre-Cambrian rocks of Yorke's Peninsula and the Mount Lofty Range offer special facilities for such a study. Not many years ago the majority of the geologists were inclined to group all rock-masses that had been subjected to regional metamorphism, and had taken on characters of a certain nature in one class and include them all under one name, such as that of Archæan.

This system was supposed to include the original crust and all sedimentary strata deposited by the water of the ocean before it had cooled down sufficiently to permit life to appear in it. By others they were considered to represent originally sedimentary rocks comparable to the later fossiliferous strata, which had been subjected to enormous compression, undergoing thereby great physical and chemical changes. In many cases the planes of foliation and cleavage were interpreted as planes of stratification. These views have undergone considerable modification. In the first place many areas of metamorphic rocks have been relegated to their proper positions in the geological record as highly-altered Palæozoic, Mesozoic, and even Tertiary sediments. It is furthermore believed that the areas coloured on the geological maps as Palæozoic, Mesozoic, and Tertiary will

still further increase at the expense of those coloured Pre-Cambrian in proportion as these areas are subjected to more rigorous and searching examination. According to some of the highest authorities of the present day the Pre-Cambrian rocks can often be divided into two great groups, one including the rocks of eruptive origin, the other those of sedimentary origin. In the first division are included the gneisses, schists, and eruptive rocks, which underlie uncomformably Cambrian strata, or, where members of the second group are developed, either underlie them unconformably or intrude them. In the latter case the gneisses are of later date than the rocks of the second group. In the second group are included the rocks, which can be proved to have had a sedimentary origin. These usually overlie the gneisses, etc., of the first group. As an example of such a classification we may take the two groups of rocks of Pre-Cambrian age, which are developed in North-west Scotland, and known as the Lewisian gneiss and the Torridon sandstone. The former underlies the latter, and the latter the Cambrian strata unconformably.

In North America the Pre-Cambrian rocks have been divided into two great groups corresponding somewhat to those made out in Scotland. The lowest and oldest, consisting of gneisses, mica, schists and granites, are included under the name of "Fundamental Complex." This great group is overlain unconformably by an enormous thickness of more or less highly altered sedimentary rocks, and intercalated volcanic lavas and tuffs.

This latter American group, to which the name "Algonkian" has been applied, has been again divided into three groups, each separated from those above and below by strong uncomformabilities. The total thickness of this latter division has been estimated at 65,000 feet.

In the uppermost strata of the Algonkian group distinct traces of fossils have been detected by Mr. Walcott.*

In Brittany too, Dr. Barrois has discovered organic remains in the form of Radiolaria in rocks of Pre-Cambrian age, which there consist of graphitic quartzites. At the meeting of the British Association for the Advancement of Science at Oxford, August, 1894, the supposed organic nature of the bodies termed Radiolaria by Dr. Barrois was called in question, the chief arguments against their organic origin being based on their very minute size, their diameter being on the average only about one-sixteenth that of the average diameter of recent Radiolaria.

The Pre-Cambrian area of Central Australia area is, geologically speaking, practically a *terra incognita*. Our visit to this inaccessible region extended over

* Tenth Annual Report U.S. Geol. Surv., 1890, Walcott, p. 552.

only a week or two, while the distance to be traversed during that time amounted to many hundred miles. The geological visits of others have been equally brief, and undertaken under similar unfavourable circumstances. Thus no detailed study of the rocks was possible; all that could be done was to gain a general idea of the whole, and to make, as far as possible, a typical collection of the rocks.

The occurrence of granite or gneiss in the McDonnell Range was made known first by Waterhouse (1) and Stuart (2), and subsequently recorded by other travellers.

Mr. J. J. East (viii., p. 51) makes the following statement:—"It is a reasonable presumption that the beds throughout" (this region, *i.e.*, from Lake Eyre to Everard Plain) "belong to one great series." As Cretaceous fossils had been found as far north as Mount Daniel, he concludes that the rocks of the whole region all belong to that system. He thus includes in the Cretaceous system strata that we now know to contain fossils of Ordovician (Lower Silurian) age, and a series of rocks underlying these unconformably, and now termed Pre-Cambrian. Such an hypothesis would have been at any time a most improbable one, and at the present time its acceptance is of course out of the question. "But should their age," continues Mr. East (referring to the rocks of the McDonnell Ranges), "be considered Archæan solely on the ground of their high degree of metamorphism?" This author attributes the metamorphism of the rocks of the McDonnell Ranges to the presence of "diorite" intrusions. This theory cannot commend itself to anyone who has observed the enormous area occupied by these rocks, and their high degree of metamorphism on the one hand, and the comparatively small size, and in places almost entire absence, of such "diorite" intrusions on the other.

This region clearly furnishes an almost typical example of regional metamorphism, in which great changes, both physical and chemical, have been produced in the rocks by extensive earth-movements.

Mr. H. Y. L. Brown (ix.) speaks of the "granite and metamorphic country," and describes the occurrence of garnets and beryl in these rocks. In the sketch-section and map accompanying that report, these rocks are called "Primary Rocks (Azoic)."

The same author (x., p. 1) describes the rocks of the McDonnell Ranges as "Metamorphic and Plutonic Primary Rocks;" and mentions as occurring there "micaceous and hornblendic gneiss, micaceous, hornblendic siliceous, and argillaceous schists and slates; syenite, garnetiferous granite, micaceous granite; epidocite; dolomite and crystalline limestone, with eruptive dykes of diorite, pegmatite and

coarse granite." He also points out that they show "signs of stratification" and "dip at varying angles." The presence of quartz reefs is also mentioned by the same author, and in a later portion of the same report a detailed description of the principal alluvial diggings, and auriferous reefs in the vicinity of Artunga is given.

Mr. Chas. Chewings (xi., p. 247) calls the series of rocks under consideration Pre-Silurian. This he did on the evidence of their unconformability and inferior stratigraphical position to rocks containing fossils ascribed by Prof. Tate to the Upper Silurian. This was, of course, under the circumstances, a safe provisional conclusion. There are, however, many weighty reasons why, in the light of our more extended knowledge of them, they should now be more definitely termed Pre-Cambrian. He asserts also that they are "distinctly stratified, with a dip in general to the north at a steep angle." He next gives what he considers to be the order of succession of the rocks, commencing from the north side of the McDonnell Ranges, as follows:—Chlorite-schist, granite, "micaceous schists and metamorphic granite, with occasional outcrops of coarse eruptive granite and other eruptive rocks," quartzite, "metamophosed clays and shales, interstratified with yellow and blue crystalline limestone."

Mr. H. Y. L. Brown (xii., p. 12) points out that, overlying unconformably "the crystalline, metamorphic, gneissic, and granitic Archæan rocks of the McDonnell Ranges, there are two other rock systems, unconformable to each other," which he calls respectively Cambrian and Lower Silurian. In a later report (xiv.) he calls these metamorphic rocks Archæan, a name which for many reasons it would be better to replace by Pre-Cambrian.

Prof. Tate, in referring to the Pre-Cambrian rocks of Australia in his Inaugural Address to the Australasian Association for the Advancement of Science in 1893,* thinks "that there are good reasons for the belief that these rocks, which exhibit the phenomenon of regional metamorphism, belong to one epoch;" and he goes on to say that "the chief evidence" (for the above statement) "is that they occupy parallel lines of elevation, having an approximate north and south bearing."

A uniform meridional trend, however, in the axis of folding of regionally metamorphosed rocks does not appear to be a safe guide as to the Pre-Cambrian age of all such Australian rocks as exhibit it, as the trend of the lines of elevation and foliation occupied by the metamorphic rocks of the McDonnell Ranges are nearly due east and west, and it is now known that these rocks are Pre-Cambrian.

* Rep. Austr. Assoc. Adv. Sci., Adelaide, 1893, p. 45.

(*b*) *Age.*

In view of the present limited state of our knowledge of these rocks it is evident that it is not advisable to employ such terms as Archæan, Azoic, etc. The first implies a greater knowledge of the relation of these rocks to those called Archæan elsewhere than we are in possession of, while the second has been shown to be inadmissable by the discovery of fossils in Pre-Cambrian rocks in North America and France. The best term, if a local name be not desirable, and that strongly recommended by Sir A. Geikie, is Pre-Cambrian. It may, however, in the present case be objected that we have no reliable evidence that these highly-altered rocks in Central Australia are older than the Cambrian, in which case a still more general term such as Pre-Silurian would be necessary. We base our belief that there is, nevertheless, every reason to consider their age to be Pre-Cambrian on the following considerations :—

1. In the first place the fact that a very strong unconformity separates them from the Lower Silurian group of rocks makes it evident that they must be either Cambrian or Pre-Cambrian.

2. We favour the latter alternative because :—

(α) The enormous differences in the lithological characters and tectonic structures of these two groups of rocks implies a vast lapse of time between their respective dates of formation.

(β) In the above-mentioned features they differ from the known Cambrian strata of Yorke's Peninsula, and from those of Flinders Range in South Australia.

(γ) Their apparent lithological and structural similarity to the Pre-Cambrian rocks of South Australia, as developed in the Mount Lofty Range.

(δ) No eruptive dykes have been noted in Central Australia amongst the Lower Silurian rocks, whereas they are very numerous amongst the Pre-Cambrian, and exhibit different stages of metamorphism in the same district, which tends to show that they have been intruded at different periods. Some were probably intruded during the Cambrian era. The process of metamorphism was undoubtedly a very slow one, extending over a lengthy period. As it progressed intrusive dykes made their appearance from time to time, the latest being, of course, *cæteris paribus*, least altered. If then the highly metamorphosed rocks of Central Australia were of Cambrian age, surely

some of the eruptive dykes, at least those that appeared last, would have penetrated the Ordovician strata.

(ε) There is an entire absence of fossils in the metamorphic group, whereas even the Lower Cambrian rocks of Yorke's Peninsula and the Flinders Range in South Australia, and of the Kimberley district in West Australia, have been proved to be fossiliferous.

The evidence obtained by us points to much of the metamorphic group having had an eruptive origin, whereas the Cambrian rocks of Australia, as far as at present known, are entirely sedimentary. No definite correlation will be attempted between this group of rocks and others of apparently the same nature elsewhere in Australia, inasmuch as no test of contemporaneity or homotaxial origin has yet been discovered for rocks of Pre-Cambrian age. Similarity of mineralogical composition cannot be depended on as a basis of correlation even among Cambrian and Post-Cambrian strata, and much less in the Pre-Cambrian.

Palæontological evidence obviously entirely fails us. Lastly, the test of its stratigraphical relations, even had Cambrian strata been proved to overlie the metamorphic group unconformably, would have been inadmissible, in view of the possible divisibility of the Australian Pre-Cambrian group, like that of North America, into a number of sub-groups, separated from each other by strong unconformabilities.

A few words, however, on the Pre-Cambrian rocks of other parts of South Australia may be of interest in this place. The best known and most important developments of undoubted Pre-Cambrian rocks are to be found in Yorke's Peninsula and in the Mount Lofty Range and its N.N.E. extension. In the Mount Lofty Range, according to Prof. Tate,* the Pre-Cambrian rocks occupy a vast monocline, dip to the S.E., and are not less than ten miles in thickness.

The peculiar feature of these rocks is the greater degree of metamorphism exhibited as we ascend in order. At the base clay-slates, quartzites, and limestones occur, undoubtedly sedimentary rocks altered to a greater or less degree. These pass upwards into mica-schist, gneiss, and even granite, rocks partly at least of a probable eruptive origin. No explanation of this apparent anomaly has been given.

At Black Point, near Ardrossan, on the east coast of Yorke's Peninsula, true Pre-Cambrian rocks occur underlying uncomformably limestones of Lower Cambrian age, containing a trilobite and coral fauna characteristic of that age.

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* *Op. cit.*, p. 47.

Some of the fossils described by Mr. R. Etheridge, jun., in his paper "On some Australian species of the Family Archæocyathinæ" came from Kanyka and Blinman, in the Flinders Range, occurring in siliceous limestones. These fossiliferous limestones, according to Prof. Tate, "overlie unconformably the metamorphic rocks which occupy the country to the eastward, bordering on the New South Wales frontier."

(*c*) *Extent.*

In journeying north from Oodnadatta a sudden and striking change is observable in the lithological character of the rocks at the point where those of Pre-Cambrian age succeed the Lower Silurian, four or five miles south of Alice Springs Telegraph Station. Leaving quartzites and limestones we at once find ourselves among rocks of a highly metamorphic character, such as gneisses and schists of various kinds.

The lowest member of the Lower Silurian series is a hard, dense quartzite, which rests inclined at a high angle unconformably on Pre-Cambrian gneiss. This quartzite rises to an altitude of from 500 to 1000 feet above the plain, and forms to a great extent the southern slope and the summit of a very prominent ridge. On the northern slope of this ridge the quartzite forms a steep perpendicular face for about 200 feet down from the summit. The remainder of the slope is formed of the gneiss.

This prominent ridge, the northern face of which exhibits the junction line between these two great systems of rocks, viz., Lower Silurian and Pre-Cambrian, is traceable almost continuously in a nearly east and west direction for many miles, at least as far as Mount Benstead on the east and Belt Range on the west. In a northern direction the Pre-Cambrian rocks extend to the Burt Plain, forming rugged mountains with intervening broken country of a rough hilly nature. Their further northern extension is concealed by a superficial covering of sand and alluvium of æolian and fluviatile origin.

This plateau, known as the Burt Plain, with its covering of comparatively recent deposits, rises to an elevation of over 2000 feet above sea level. Out of this plateau there rise the Strangways, Reynolds, and Hart Ranges, all probably composed of these ancient rocks.

The Hart Range, where examined, viz., near Mount Brassey, and again twenty to thirty miles west of that point, was found to be entirely composed of these rocks. Their eastern and western boundaries are not known. Southerly

they disappear under the quartzites and limestones of Lower Silurian age, appearing at the surface, according to Mr. East, as a low ridge, which crosses the bed of the Finke eighteen miles above Crown Point Cattle Station. Still further south they probably form a great part of the Peake and Dennison Ranges; and lastly, a great part of the country to the east of Flinders Range is composed of them—at all events of Pre-Cambrian rocks—being in several localities found to be overlain by strata containing Cambrian fossils. In the McDonnell Ranges alone they occupy an area of at least 10,000 square miles.

(*d*) *Structural Features.*

Messrs. Brown and Chewings both state that the Pre-Cambrian rocks are distinctly stratified, and have a definite and determinable dip. No evidence is given in support of these statements, which must therefore be received with caution. In the first place they appear to be conclusions from the unwarrantable assumptions that the rocks of this region are metamorphosed sedimentary strata, and that the planes, which are so strongly marked in many localities, are those of bedding.

The evidence in favour of the eruptive origin of large areas of the Pre-Cambrian rocks will be gone into more fully later. In the meantime we may point to the porphyritic gneissic granite on which Alice Springs Telegraph Station is situated, and which covers a large area, and to the augen-gneiss with lenticular "eyes" of comparatively unaltered granite embedded in a ground mass of crushed granitic minerals, as being strong evidence of the eruptive origin of rocks covering large areas.

Although it may be possible and even in places probable that the planes, which are so strongly developed, coincide with the original planes of stratification in any large area where sedimentary rocks may have been developed, yet as a general rule there can be no doubt that these planes represent foliation planes. This statement is greatly strengthened by the facts of the coincidence over large areas of the strike of these planes, and of their great persistency; for they are traceable not only through rock-masses, the eruptive origin of which it highly probable, but also even through undoubted intrusive dykes. They are, therefore, planes of foliation, of stratification-foliation—that is, of foliation corresponding with the original bedding planes, it may be in places; but elsewhere assuredly they appear to be those of cleavage-foliation.

The foliation and extreme degree of schistocity, and the development of planes of shearing and cleavage resulting from the yielding of the rocks to the lateral

crust-pressure, give the rocks a bedded appearance. When, however, we trace these pseudo-strata along the surface in the direction of their strike, we find that many of them are not persistent even for short distances, but pinch out so as to have the shape of lenticular masses. When therefore we speak of the direction of strike and angles of dip of these Pre-Cambrian rocks, such terms must be considered to apply to the planes of foliation. Rocks exhibiting all degrees of foliation appear to be present from the coarse-banded gneissic granite from Alice Springs, in which the foliation is scarcely noticeable in hand specimens, to such finely-banded gneiss as that which is largely developed near the head of Ellery's Creek. In the Belt Range the dip of the foliation planes increases from 40° on the south to 60° and 70° on the north side of the range. The foliation planes of the gneiss near Slip-panel Gap, about sixty miles west of Alice Springs, strike N.E. and S.W., and dip at high angles to N.W. Further east, on the south side of Mount Conway, the strike was found to have changed to E.N.E. and W.S.W., the dip being about 70° S.S.E. Still further to the east, between the last-mentioned place and Alice Springs, the strike was observed to be E.S.E. and W.N.W., while the dip had decreased to 37° S.S.W. To the north and south of Alice Springs the foliation planes of the gneiss dip at 40° to 50° S.W., the strike being N.W. and S.E.

In the McDonnell Ranges, to the east of Alice Springs, the strike was the same as that noted north and south of Alice Springs, but the dip had decreased to 25° S.W. On the banks of Jessie Creek, ten miles east of Alice Springs, the strike of the gneiss forming the low hills there was N.E. and S.W., and the dip about 40° N.W. In the Hart Range the planes of foliation were found to be well marked; their strike varies from W.S.W. and E.N.E. to S.W. and N.E., and the dip observed varied from 50° to 60° in a direction varying from N.N.W. to N.W. Lastly, in the Strangway Range, at Winnecke's Depot, the gneiss was seen to dip at 45° N. 10° E. There is a remarkable absence of evidence of the original planes of foliation having been subjected to any subsequent contortion, on either a large or a small scale, a fact which seems to imply that the direction of the pressure was constant for a prolonged time, and that the rock-masses were able to find relief from the stresses to which they were subjected by the development of gliding planes and sheer planes.

(*e*) *Material Geology.*

The rocks of this group may, for purposes of description, be roughly classified as follows:—

1. Those whose sedimentary origin is evident.

2. Those about whose origin there is considerable doubt, including a great part of the gneisses.
3. Those that are clearly of eruptive origin.

1. The only representatives of this division met with were the quartzites and micaceous slates, whose exact stratigraphical position is rather doubtful. The Pre-Cambrian at Gill's Pass, on the Hugh River, is introduced by a thick mass of quartzite, succeeded by micaceous schists and gneiss; and in Stuart's Pass, too, quartzites are intercalated as we approach the axis of elevation in the gneissoid granite of Brinkley's Bluff. Representatives of this division were also found near the head of Ellery's Creek, forming an elevated ridge (*vide* Fig. 1*b*) on each side, of which undoubted Pre-Cambrian rocks occur in the form of gneisses and schists, accompanied by intrusive rocks. This ridge is composed of highly-altered glassy quartzites and micaceous clay slates, apparently passing into mica schist, quartzites, and clay slates, which dip at 85° N., their strike being W. 10° N. We have not enough evidence to determine whether or not these rocks belong to the Pre-Cambrian. Their relation to the gneisses on the south and north sides of the ridge was not made out. It is therefore quite possible that they may belong to the Ordovician System, and form a portion of a northern extension of that system, which had been faulted down so as to present the appearance of forming part of the Pre-Cambrian System. On the other hand, it is also possible that they may represent Pre-Cambrian sedimentary strata, which have been intruded by granites of Pre-Cambrian age, the latter being now represented by the gneissic granite to be found on the south of this ridge, and by the gneiss, etc., occurring on both sides of it.

2. Numerous varieties of gneiss occur within the Pre-Cambrian area, some of which will be briefly described in a separate paper dealing with the microscopic characters of these rocks.

Specimen No. 29 represents a very typical variety of gneiss occurring in the McDonnell Ranges. It is strongly foliated, but the folia, which usually have a thickness of from quarter to half inch, are not very persistent. They pinch out, occasionally very rapidly forming lenticular masses, which usually in this variety are much drawn out. These lenticular masses are sometimes, however, very short and "eye"-like. The folia, which consist for the most part of quartz, felspar (a great portion of which is a plagioclase with low angles of extinction), and a few grains of biotite, are separated from one another by thin black layers of biotite not more than one-eighth inch thick. These thin layers of biotite are usually roughly parallel to one another, but occasionally they intersect.

Specimen No. 97 is an example of a gneiss which exhibits a more advanced stage in the production of "eyes" than that just described. This variety of gneiss, which was met with on the north side of Brinkley Bluff, was observed to extend over a large area in the McDonnell Ranges.

In this specimen the felspar and quartz are not so distinctly marked off into folia separated by thin more or less parallel layers of biotite. They seem, however, to be much crushed, and, together with the biotite, to form, as it were, a ground mass to the lenticular portions.

These lens-shaped masses usually show when examined carefully their relation to the remainder of the rock, by the presence of narrow laminal running out from them into the mass of the rock.

Another specimen (No. 4) seems to mark a further stage in the process of metamorphism; it was obtained from an outcrop in the bed of Maude Creek, which takes its rise on the southern slope of Hart Range, and is a typical representative of a gneiss found extending over a large area.

The finely-foliated structure is not so well marked in it as in the above-mentioned specimens. There seems to have been a greater movement of the constituents during crushing, the fine portions of which wrap round the lenticular masses in such a manner as to simulate the "flow-structure" so well developed in many volcanic rocks with porphyritic crystals.

The "eyes" are entirely isolated, and consist chiefly of quartz and felspar, while in the ground mass are to be seen quartz, felspar, biotite, and garnets.

A gneiss from Belt Range (No. 34) resembles in structure specimen No. 4. In the former, however, the "eyes" are composed of microcline, and are embedded in a crushed mass of felspar, quartz, and a small quantity of decomposed mica.

3. Those that are clearly of eruptive origin:—

(*a*) Rocks of the Acid Group.

"Oolgarna" granite. The granite from which the immense crystals of mica are obtained, at the Oolgarna Claim in the Hart Range, is composed of the usual constituents of ternary granite, viz., quartz, felspar, and mica. As the felspar belongs to the triclinic division, the rock ought to be termed a granitite. Although all the constituents are developed on an enormously large scale, the crystals being often from two to three feet in diameter, no one particular mineral is porphyritically developed. The felspar is of two kinds—a potash variety, which invari-

ably exhibits the characteristic "cross-hatching" of microcline, and a plagioclase belonging to the soda end of the soda-line series, with very low extinction angles and very fine polysynthetic twinning. The mica is also of two kinds, a black variety biotite, and the potash variety muscovite. Beryl and tourmaline occur as accessory minerals.

The granitite from an intrusive dyke on the opposite (western) slope of the mountain spur to that on which the Oolgarna Claim is situated has an almost identical mineralogical composition to the Oolgarna rock. There are the same two varieties of felspar, a microcline and a plagioclase, with well-developed polysynthetic twinning and small extinction angles. Of the micas, muscovite alone appears to be developed in this dyke, and hugs in a marked manner its southern wall. Here also tourmaline and beryl occur as accessory minerals, with the addition of some small red garnets. A crystal of beryl was obtained from this rock, which measures three inches in diameter and six inches in length. Its form is that of a perfect hexagonal prism, the terminal ends of which are not present. It exhibits macroscopic zoning, the several zones of the mineral having a slightly different tint, with a central nucleus of quartz and felspar. Its colour varies from pale green to yellowish green. The plates parallel to the basal plane, obtained by taking advantage of the somewhat imperfect basal cleavage, were found to yield in convergent polarised light excellent interference figures having a negative sign. Some of the hand specimens from this dyke consist entirely, or nearly so, of felspar, sometimes microcline, at other times a soda plagioclase; others consist entirely of quartz and muscovite, while yet others again consist entirely of mica. The order of crystallisation, as determined from the hand specimens, is mica, quartz, and felspar. The felspar has crystallised out last, as it frequently encloses entire crystals of quartz and mica. The mica has crystallised out first, for where the quartz comes into direct contact with a crystal of mica its (the quartz) outline is found to have been determined by that of the mica.

A specimen (No. 93) which was obtained in the McDonnell Ranges, near the head of Ellery's Creek, represents a type of gneissic granite, which is not uncommon in these ranges. There can be no doubt that it is a granite which has undergone a certain amount of crushing, but not enough to make its origin a matter of doubt. It consists for the most part of microcline and quartz, which are often intercrystallised in a manner similar to that observed in graphic granite. The rock in the hand specimen does not appear to be foliated, whereas, in the field, a coarse-banded foliation was observed. Masses of intercrystallised microcline and quartz are separated by thin irregular laminæ of biotite flakes.

A second specimen (No. 96) is a gneissoid granite from Alice Springs with large porphyritic microcline crystals. The mass of the rock scarcely exhibits foliation in hand specimens, but when examined in the field it is found to be distinctly foliated. It consists of quartz, felspar (microcline), and two varieties of mica, biotite and muscovite, of which the former is most abundant.

A third specimen (No. 139) is from a dyke intruding gneiss near the head of Ellery's Creek. It consists of grey quartz, muscovite, and a white rather opaque plagioclase exhibiting very fine twin lamellation parallel to 0·10, and very low extinction angles. This granite resembles in its mineralogical composition, and its structure, that occurring on the north side of Hart Range, which latter has yielded the very large mica crystals. Many of the gneisses, especially in the vicinity of intrusive masses, are found to contain epidote, sometimes in large quantities. The epidote sometimes occupies small veins in the gneiss; at other times it is found to be present in the form of irregular grains throughout the mass of the rock.

(*b*) Intermediate group.

Near the Oolgarna mica-claim a fine-grained intrusive rock occurs, which is, at first sight, not unlike a basalt, though somewhat lighter in colour. In thin sections it proves to be a granulitic pyroxene diorite with much hypersthene, and a fairly large quantity of magnetite and uralitic hornblende.

(*c*) Basic Group.

Between Slip-panel Gap and Ellery's Creek a large number of dykes of basic rocks occur intruded amongst the gneisses, etc. The strike of these dykes is usually N.W. and S.E., some of them being traceable on the surface for long distances. One dyke was observed to be as much as 600 feet in width, the rock of which it is composed being an olivine dolerite. The basic rock of one of these dykes proved to be a gabbro (No. 109) consisting of diallage, a plagioclase with an extinction angle about that of labradorite, and magnetite in large grains. Another of these basic rocks (Nos. 195 and 179) appears to be an olivine dolerite, consisting of plagioclase, augite, a considerable quantity of undecomposed olivine, magnetite, and a few grains of hypersthene. Ophitic structure is well developed, in which large irregular masses of augite enclose a number of felspar crystals. Another rock (No. 64) is a diabasic dolerite, in which much of the felspar and augite is decomposed resulting in the production of epidote, chlorite, fibrous hornblende and, perhaps, saussurite.

III.—Ordovician.

(*a*) *Introductory.*

If the group of metamorphic rocks just described be considered Pre-Cambrian, then the Cambrian is altogether unrepresented; and either sedimentation never took place over the area now exposed, or if it did, the materials so deposited were entirely denuded off from this area during the long interval separating the conclusion of their deposition and the disappearance of this region beneath the waters of the Ordovician sea.

Messrs. Brown and Chewings, however, have at various times argued, on what appears to us insufficient evidence, that the age of certain strata flanking the McDonnell Ranges on the south is Cambrian. Thus Mr. Brown (x., p. 2) in 1890 examined in the vicinity of Heavitree Gap, to the south of Alice Springs, a series of rocks resting unconformably upon the "Metamorphic and Plutonic Primary rocks" of the McDonnell Ranges, and called them "Primary rocks (Cambrian ?)." He included in this series "quartzites (sometimes conglomeratic), dolomitic limestone and occasionally clay-slates." "They vary," according to this author, "in dip and strike, are often much twisted, contorted, and dislocated. . . . And the granite and other dykes and quartz reefs do not extend into these rocks, nor have fossils been observed in this formation."

In 1891 Mr. Chewings (xi., p. 249) did not include Cambrian in his classification of the rocks of this district, the rocks of Mr. Brown's Cambrian being partly included by Mr. Chewings in his Pre-Silurian, and perhaps partly also in his Silurian.

In the same year Mr. Brown (xii., pp. 12, 13) says:—"Lying unconformably on the crystalline, metamorphic, gneissic, and granitic Archæan rocks of the McDonnell Ranges, there are two other rock systems unconformable to each other. The lower of these two systems," he continues, "consists of quartzite, quartzite conglomerate, dolomitic limestone, limestone, sandstone, and slate, striking east and west. They are lithologically similar, and doubtless of the same age as the quartzite, dolomitic limestone, limestone, sandstone, and slate series of the Flinders and other ranges in the northern part of South Australia proper (in the limestone of which fossils of Cambrian age have been identified by Mr. Etheridge . . .), the Dennison and Peake, Mount Dutton, and ranges to the west of the Musgrave and in the neighbourhood of Mount Burrel. . . ."

It is unfortunate that Mr. Brown gives no account of the evidences of the unconformability between this series of rocks and his upper system, which contains fossils determined by Mr. Etheridge to be Lower Silurian.

In the following year Mr. Brown (xiv., p. 7), again classifies the quartzites, dolomite, limestone, sandstone, and slate, which overlie the Pre-Cambrian rocks unconformably, as Cambrian. He includes in his Cambrian series the rocks occurring between Mount Sonder and the northern boundary of the alluvial plain of the Finke, north of the Lutheran Mission Station. There is also on p. 11 a geological sketch-section showing the relations of the rocks of Mr. Brown's Cambrian system to those above and below.

Two sets of observations made by us prove fatal to Mr. Brown's establishment of a Cambrian System in Central Australia. The first is the presence of fossils of Ordovician age occurring in a dense grey quartzite and in a reddish argillaceous limestone (*vide* Section McDonnell Range to Levi Range), almost identical with that found on the north side of George Gill and Levi Ranges, and recognised to be Ordovician by Mr. Brown. The quartz-grits also associated with limestone at Deep Well, and both limestones and associated gritty sandstones at Chandler's Range contain Ordovician fossils. The second is the discovery of water-worn fragments of the red Ordovician limestone containing characteristic fossils in the uppermost portion of the immense bed of conglomerate and conglomeratic sandstone, which overlie the quartzites and limestones of Ordovician age (*vide* Section McDonnell Range to Levi Range), and which form the northern boundary of the Missionary Plain, north of the Lutheran Mission Station. The red argillaceous limestone, mentioned above, was found outcropping on the northern side of Horn Valley, which is a longitudinal valley of great length separating two quartzite ridges. The actual locality where this fossiliferous limestone was observed is situated ten miles west of the Finke Gorge. The limestone, charged with *Orthis leviensis*, was observed to be dipping to the north at a very steep angle, and to be overlain by quartzite. It was in this quartzite, at a point a few hundred yards south of the northern end of the Finke Gorge, that *Endoceras* and other Ordovician fossils were also found. Thus in the very centre of Mr. Brown's so-called Cambrian System, and in rocks forming an important part of it, Ordovician fossils have been found.

The second piece of evidence determines, without a doubt, the age of the conglomerate, also included in Brown's Cambrian System, to be not Cambrian but Post-Ordovician. In view of the evidence just mentioned there can be no doubt that we are perfectly justified in considering the strata (excepting the Post-

Ordovician conglomerate) as far north as the northern edge of the Finke River Gorge as Ordovician. To what system the strata, that lie between this point and Mount Sonder, belong we have no palæontological evidence to show. Owing to the absence, however, of any signs of unconformability, we are of opinion that they belong to the Ordovician System. There does not appear to be a great thickness of strata on the south of Mount Sonder, as an inlier of gneissic granite belonging to the Pre-Cambrian system is visible in the valley of the Davenport. The rocks composing Mount Sonder and the low hills to the south consist of quartzite, micaceous slates, and dolomitic limestone highly altered by the earth movements, which seem to have been greatest here, and to have decreased in force southwards. For this reason these rocks appear more altered than the typical Ordovician rocks further south. We therefore cannot adopt Mr. Brown's classification, because we have undeniable evidence of the Post-Ordovician age of one part and of the Ordovician age of another, and lastly, because no reliable evidence has been furnished of the Cambrian age of the remainder. Rocks of Cambrian age constitute a large part of the Flinders Range, being certainly known to be developed as far north as the Ajax Mine, between Beltana and Leigh's Creek, where fossils similar to those found at Parachilna, Blinman, and other localities in the Flinders Range, and described by Mr. R. Etheridge, Junr., have been discovered.

In 1894 Mr. Chewings (xv., p. 198) pointed out that annelid burrows are present in the quartzites on the north side of Mereenie Bluff, and considers that these rocks may be Cambrian. Similar annelid burrows were found by us in a quartzite range, which appears to be an eastern extension of that spoken of by Mr. Chewings. Some of the quartzite yielded to us other fossils, which fix its age as Ordovician, and no doubt determine the age of the ridge referred to by Mr. Chewings to be also Ordovician. In the same paper Mr. Chewings includes under his heading Cambrian and Pre-Cambrian (?) the rocks occuring in the valley of the Davenport. Our reasons against such a view have just been given.

In 1889 Mr. Brown (ix., p. 2) described the occurrence in the vicinity of Mount Burrell of limestone with flinty veins, quartzite, sandstone, and slates, which he judged, basing his conclusions on lithological evidence, to be of the same age as his so-called Silurian rocks of Anna Creek and Finnis Springs. These latter bear every appearance of being northern inliers of the series of rocks, which constitute a great portion of the Flinders Range, and which, at least as far north as the Ajax Mine, have been lately proved on palæontological evidence to be Cambrian. There is no doubt that the Mount Burrell strata belong to the

Ordovician System of rocks so strongly developed to the north of Mount Burrell and between this point and the McDonnell Ranges, and which have now yielded Ordovician fossils in so many localities.

In this report Mr. Brown distinguishes an overlying series "composed of brown and white sandstone in horizontal and inclined layers," and called by him Devonian (?); but as this author in a later report (xiv., p. 7) relinquishes this division, it will not be necessary to make any comment.

In his topographical description of the country lying between the Flinders and McDonnell Ranges, Mr. East (viii., p. 31) treats the subject under three headings, viz., (1) "The Great Austral Plain," (2) "The Terraces," and (3) "The Great Central Plateau." Had Mr. East divided this area geologically into three corresponding divisions, the rocks of each belonging to one of the geological systems, he would have made an approximation to the truth. If he had called the rocks occurring in the area included in his first topographical division Cretaceous, those of the second Silurian, and those of the third Pre-Cambrian, he would have given an infinitely superior geological classification than that suggested by the following statement (viii., p. 51):—

"With regard to the geological age of this region" (between Lake Eyre and Everard Plain on the north side of the McDonnell Ranges) "the presence of fossils on the face of the slope up to an altitude of 800 feet" (referring probably to the discovery by himself of *Lingula subovalis* at Mount Daniel) "places us on pretty sure ground and shows the age of deposition to be Mesozoic, and probably Cretaceous. Farther up the slope there must exist doubt until fossils are actually discovered, though it is a reasonable presumption that the beds throughout belong to one great series."

In criticising this statement it must be borne in mind that it was not until two years after the publication of Mr. East's paper that Lower Silurian fossils were first described from Central Australia. After making due allowance, however, for the absence of palæontological evidence to the north of Mount Daniel, it is difficult to understand how any geologist, who had travelled over the Cretaceous, Silurian, and Pre-Cambrian rocks, could formulate such a theory. The rocks of the three systems under consideration differ from one another in lithological characters and structural features as much as it is possible for any three sets of rocks to do. Not only so, but the change in these features is sudden and well-marked, even though the actual junction-line itself be not observed. Thus the Cretaceous rocks have very characteristic lithological characters, and dip at

extremely gentle angles (usually at an angle of not more than two to three degrees) throughout the area occupied by them; while the Silurian rocks, consisting of sandstones, quartzites, and limestones, unlike the Cretaceous, dip at from 40° to 50° in the vicinity of the junction-line of the two formations. Again, on leaving the Lower Silurian area at Heavitree Gap, for instance, the differences, both lithological and structural, to be observed in the two sets of rocks ought to attract the notice of even the most casual observer.

In 1890 Mr. Brown (ix., p. 6) placed the quartzites, dolomitic limestone, and clay slates, which are seen to rest unconformably on the Pre-Cambrian rocks at Heavitree Gap and elsewhere, and which appear to be unclassified in the sketch section accompanying his previous report, in a group by themselves, which he calls Primary rocks (Cambrian ?). On a study of Mr. Brown's later reports (xiv. p. 7) it will be observed that he retains this division, but extends the area of the rocks included in it as far south as the Lutheran Mission Station, absorbing thereby part of his former Silurian rocks. In 1891, after the determination of the Lower Silurian age by Mr. R. Etheridge, Junr., of the fossils submitted to him by Mr. Brown, his (Mr. Brown's) original Silurian became Lower Silurian, and, as more clearly stated, was made to include the rocks of the George Gill, the James, and Ooraminna Ranges. Thus the rocks which in 1890 were classified as Devonian (?) are now included in the Lower Silurian.

In 1891 Mr. Chewings (xi., pp. 249–252) called a portion of the system of rocks under consideration Silurian, basing his classification on the determination of the Silurian age of the fossils collected at the head of the Walker River, at Mereenie Bluff, and on the Petermann Creek. This author separates from this system the Ooraminna sandstone and the conglomerate which flanks the South McDonnell Range. The Ooraminna sandstone, as there is every reason to believe, belongs to the Ordovician system, but we have positive evidence of the Post-Ordovician age of the conglomerate.

In a note to this paper of Mr. Chewings's, Prof. Tate (xi., p. 255) gives a list of the fossils identified by him, and from the meagre evidence afforded by them was inclined to assign an Upper Silurian age to them. Mr. Chewings's Devonian of the George Gill Range is identical with the red sandstones overlying the fossiliferous Ordovician limestones, which sandstones have there a very low dip, but are, nevertheless, superimposed conformably on the limestones, which outcrop in Petermann Creek (*vide* Fig. 7). The Tertiary deposits of the same author are outliers of the same range, which, because of the low dip and the fact of their

being seen from the south in their strike-plane, present the appearance of an unconformable capping.

In 1891, in his paper entitled "Descriptions of some South Australian Silurian and Mesozoic Fossils," Mr. R. Etheridge, Junr.,* described the following Lower Silurian fossils:—*Raphistoma brownii*, *Orthoceras sp. ind.*, and *Orthis leviensis*. In a note in the same report Mr. Brown describes the discovery of these fossils in September, 1890. In this report, and two subsequent ones, Mr. Etheridge assigned the fossils to a Lower Silurian age. A complete account of the fauna will be given in Part V.—PALÆONTOLOGY.

As has been mentioned already, we eliminate Cambrian from our classification of the rocks occurring within the region under consideration (from Oodnadatta to the McDonnell Ranges) for the reasons that have been detailed. We include in the Ordovician system all the strata lying between Mount Burrell Cattle Station on the south and the McDonnell Ranges on the north, with the exception of the conglomerate which was observed on the north side of Rudall's Creek, and on the banks of Ellery's Creek north of the Lutheran Mission Station (Hermannsburg).

(*b*) *Extent.*

In the journey north from Oodnadatta the first outcrop of Ordovician strata was seen about seven miles north of Francis Well on the Hugh River, and about the same distance south on the Mount Burrell Cattle Station, which is also on the Hugh. The southern boundary of the Ordovician area extends westerly from this point, passes a few miles south of Chandler's Range, and thence sweeps round the southern faces of Levi and George Gill Ranges, and perhaps continues for many miles further west. East of Mount Burrell the southern boundary is not known. The northern limit of this area is partly formed by the prominent quartzite ridge, in which are the Heavitree, Emily and Jessie Gaps; but at Mount Sonder, and to the west of it, there are beds which intervene between this quartzite and the Pre-Cambrian rocks.

The above-mentioned ridge is traceable for about twenty-five miles east of the first-named gap, beyond which it sweeps suddenly northwards; so that in journeying due east we find the Pre-Cambrian rocks overlain by a northern extension of the Ordovician strata. The northern boundary of the Ordovician rocks north of Mount Benstead, and east of that point, has not been traced. In journeying nearly due east of Mount Benstead, and at a distance of about twenty-

* Reports on Coal-Bearing Area in Neighbourhood of Leigh's Creek, Adelaide, 1891, pp. 9-14, pl. i.-iii.

eight miles from that place, the track emerges from the Ordovician Ranges, through which it had led for that distance, on to Pre-Cambrian gneiss. To the north, from two to three miles distant, a somewhat elevated quartzite range is to be seen forming, in all probability, an outlier of Ordovician strata. To the south another quartzite range was seen, which probably constituted the northern limit of the main Ordovician area. Between these two ranges the Ordovician strata have been entirely removed, exposing the Pre-Cambrian rocks at the surface, which have been eroded into characteristic low, rounded, "jumbly" hills. Eastward from this last point the Ordovician rocks lie wholly to the south, the northern quartzite range dying out after a short easterly course.

At Arltunga (Paddy's Hole) the northern boundary lies a mile or two south of the mining township, its further eastern course is not known.

Westward of Alice Springs the quartzite ridge, which marks the northern limit of the Ordovician strata, continues to Mount Gillen, where it sweeps S.S.W. (about). In this face is an opening known as Temple Bar Gap. The range continues a short distance south of this opening, and then turns westward past Burt's Bluff; still further west it continues to Mounts Sonder and Zeil, and Belt Range. The western boundary of this area is not known; but judging by the observations of Mr. Tietkens, these rocks extend across the West Australian border.

(*c*) *Stratigraphical Relations.*

The lowest stratum of the Ordovician System found directly overlying the Pre-Cambrian gneiss a few miles to the south of Alice Springs is a dense grey quartzite (*vide* Fig. 2 *b*). The junction-line between this quartzite and the gneiss, where not concealed by a talus of quartzite, is seen to be uneven, and more or less undulating; a fact which, coupled with the great fundamental differences of a lithological and structural character, evidently points to the presence of a strong unconformability, separating these members of the Ordovician and Pre-Cambrian Systems. The same features are seen in Belt Range, as indicated by Chewings (xi.) at Haast Bluff, but not Haast Bluff of Giles. Here friable gritty sandstones and quartzite, aggregating 1500 feet in vertical thickness, repose in an east and west direction on an undulating surface of schistose rocks, and over which they transgress in a south and north direction (see Fig. 3 and Section from Mereenie Bluff to Belt Range). Similar appearances are presented in Mount Zeil, as seen from a distance of three-and-a-half miles; here a crown of quartzite transgresses over schistose rocks, which have conspicuous planes of foliation dipping north at a high angle.

At Gill's Pass the Ordovician limestones, dipping south, come into contact by a fault with a glassy quartzite (forming a high, scarped ridge), which introduces the Pre-Cambrian rocks, which continue uninterruptedly northward to Burt Plain with high planes of foliation dipping north (see Section from Missionary Plain to Gill's Pass). Although the actual junction line was not observed, there is strong evidence that the Ordovician limestone and quartzite and the Post-Ordovician conglomerate, already referred to, are unconformable to each other. In the lowest strata of this conglomerate among pebbles of other rocks were found waterworn fossiliferous fragments of the red crystalline limestone belonging to the Ordovician System. Thus the Ordovician limestone must have been consolidated, upheaved above sea-level, and eroded before the formation of this conglomerate.

The actual junction-line between the Ordovician and the Cretaceous was not observed. The great difference in the amount of dip of the strata of the two systems, even close to the junction, as observed a few miles south of Henbury Cattle Station on the Finke, gives some idea of the strong unconformability that must exist between the rocks of the two systems. At Henbury itself small outliers of horizontally bedded chalcedonized sandstone, so characteristic of the Cretaceous, rest on Ordovician argillaceous limestone, dipping at a moderately high angle to the south-east, the actual contact being concealed by the waste from the overlying bed.

(*d*) *Structural Features.*

Folding.—The Ordovician rocks have been thrown into a number of folds, gentle in the south as in the George Gill and Levi Ranges, and becoming sharper in the north. In the ranges just mentioned the rocks, chiefly sandstone, dip at low angles, viz., from 8° to 10° to the south on the north side, and about the same amount in an opposite direction on the south side. Thus the rocks of these ranges form a shallow synclinal trough; the corresponding arch, probably originally situated on the north side of these ranges, has been entirely removed by denudation and erosion, its place being now occupied by the valley of Petermann Creek. At Mount Sonder and in the valley of the Davenport to the south, at the opposite edge of the Ordovician area, the strata have suffered the greatest amount of disturbance. There quartzite, alternating with micaceous shale and passing below into dolomitic limestone, is dipping at high angles to the north (see Section McDonnell Range to Levi Range).

Absence of Eruptive Rocks.—A somewhat remarkable feature of this ancient system of rocks is the total absence, as far as observation goes, of eruptive rocks,

whether plutonic or volcanic. There is no evidence either of the presence of intrusive dykes or sills, or of interbedded lavas or tuffs throughout the whole area examined.

False-bedding.—False- or current-bedding is strongly developed in the sharp gritty sandstones at Glen Edith, and on the north side of the range which forms the southern boundary of Shake's Plain, which is known locally as the Station Range, situated on the south side of Tempe Downs Cattle Station. There the current-bedding is so well developed that one is apt at first sight to mistake the false-bedding planes for the true-bedding planes. The former, however, are seen to vary so rapidly in the direction of their dip that the mistake can be easily rectified, and the true bedding planes made out without much trouble.

Ripple-marks.—The surface markings known as ripple-marks are well exhibited by the sandstone constituting the Levi and George Gill Ranges. In the Levi Range, where they were particularly noted, the alternating ridges and furrows were seen to have a very varying trend, at one time in a N.W. and S.E. direction, and at another in a N.N.E. and S.S.W. direction. The width of the ridges, as also of the furrows, was about one inch, and the height from the bottom of the furrow to the crest of the ridge about half an inch. In George Gill Range, where ripple-marks were seen to be extensively developed, the sandstone is evenly and thinly bedded, and the surfaces of many succeeding laminæ were seen to be ripple-marked. The evidence deduced from the presence of these ripple-marks indicates shallow water deposition of the strata in which they occur; that is of the sandstone of George Gill and Levi Ranges. Ripple-marks were also observed in the quartzite forming the walls of Heavitree Gap, and in the quartzite near the northern extremity of the Finke Gorge.

Concretionary Structure.—Concretionary masses composed chiefly of hydrated oxide of iron occur in the fossiliferous limestone on the south side of George Gill Range. Concretions of a siliceous nature were observed in the siliceous limestone flanking the Mount Gillen quartzite ridge on the south. A concretionary limestone was also observed in the Finke Gorge.

Sedimentation in Relation to Physiographic Changes.—A natural cycle of sedimentation bearing a definite relation to the physiographic changes, through which the locality under consideration has gone through, can be made out in certain portions of the Ordovician strata. The northern half of George Gill Range, for instance, is composed of sandstone dipping to the south. This is followed on the north in regular descending order by calcareous shales or, perhaps

more strictly, by soft argillaceous limestone, and this by hard red limestone comparatively free from argillaceous matter, and this latter by a great thickness of sandstones and quartzites. The lowest strata, and those first deposited, bear indications of shallow water deposition, probably on a sinking sea-bottom. The next strata, the limestones, point to deeper water conditions and practical quiescence, although the water still remained muddy, as evidence by the somewhat argillaceous character of the limestone, and by the presence of trilobites and rarity of corals. The strata next in ascending order indicate upheaval and deposition in shallower water, these strata being much less calcareous and more argillaceous than the preceding limestone. Lastly, on top we have a great thickness of sandstones, the uppermost layers especially, which are ripple-marked to such a great degree, and which contain pebble bands, as in the Glen of Palms, Laurie's Creek, etc., pointing to deposition in very shallow water.

Dip.—The strata of the Ordovician system dip at very varying angles. As a general rule, however, it may be said that the dip increases as we go northwards. This has its explanation in the more highly-disturbed state of the rocks in the northern portion of this area. The three following series of observations on the dip of the strata will give some idea of the steady increase in the angle of inclination of the strata in a section across one arm of a fold:—

1. Levi Range northwards for a distance of about four miles 9°, 14°, 14° 30′, 17°, 22°, and 37°.

2. From Bowsen's Hole in a N.W. direction. At Bowsen's Hole the dip was 10°; at 3 miles was 15° – 20°; at 4, 30°; at 6, 35° – 40°; at $6\frac{3}{4}$, 45° – 50°; at 8, 70°; at $8\frac{1}{2}$, 75°; at 14, 80°.

3. At the western extremity of the Mereenie escarpment, which constitutes the wall-like southern boundary (rising to nearly 1000 feet) of Horn Valley, the dip of the fossiliferous limestones is 37° S. 5° W. At the entrance to Stoke's Pass (three miles due north) the dip of the quartzite, which forms the northern wall of Horn Valley, was found to have increased to 60°; and that of the underlying beds to increase still further to their northerly termination.

(*e*) *Detailed Sections.*

1. Section through Levi and James Ranges (*vide* Section McDonnell Range to Levi Range). A traverse across Levi Range revealed the fact that the sandstone composing this range has the form of a shallow synclinal trough. Levi Range has a steep escarpment on its north and south faces

from three to four hundred feet high. The dip of this sandstone varies from 6° to 8° on the north and south faces of the range, while about its centre the dip changes, within the distance of half a mile, from 4° S.S.W. to 4° N.N.E. On the summit of the northern escarpment the sandstone exhibits well-marked false or current bedding, and the surfaces of the strata are ripple-marked. This sandstone, which as a rule is fairly indurated and often approaches a quartzite, in other places is of a white friable felspathic nature, indurated in places by secondary silica. No fossils were discovered in this sandstone. Underlying this is a yellowish thinly-bedded indurated mudstone, with more or less perfect cubes on the weathered surfaces, which may represent pseudomorphs after some mineral, probably rock salt. The cubes vary from about an eighth of an inch to over half an inch in diameter, the faces being concave. Underlying this latter rock quite conformably are the fossiliferous limestones, which have yielded a small number of Ordovician fossils. This limestone varies much in character when traced in the direction of its strike for any distance. It is, however, always very argillaceous, and varies from a grey to a yellow and very often red colour.

On the north side of Levi Range it dips at an angle of 14° S.S.E., and appears to be quite conformable to the sandstone of the range. It has yielded numerous specimens of *Orthoceras* and *Endoceras*, besides many specimens of *Raphistoma brownii*. The same series of rocks are to be made out to the west of Levi Range. In the George Gill Range the sandstone has most of the characters exhibited by the same rock in Levi Range, with the addition of a finely-bedded structure, well seen in Martin's Pass.

The uppermost zone is very rich in *Orthis leviensis*, while below come beds enormously rich in Trilobite fragments. Quartzites underlie these limestones on the north, the uppermost strata being apparently unfossiliferous. They dip at 14° (about) in a S.S.W. direction, and are succeeded a little further north by fossiliferous quartzites dipping 17° S.S.E. The total thickness of Ordovician strata between Levi Range and the point to the north of it, where the dip becomes reversed about three-and-three-quarter miles north of Camp 25 on the bank of Petermann Creek, is 7000 feet.

At the top of the series are 560 feet of red sandstone, exhibiting current-bedding and ripple-marks. Levi and George Gill Ranges are composed entirely of this rock. Below this come 440 feet of yellow and grey mudstones and earthly limestones and yellow and red argillaceous limestones, in the lowest beds of which the majority of the fossils have been found. Lastly, below the limestones there are

6000 feet of sandstones and quartzites, some small part being composed of thinly-bedded, highly argillaceous sandstone, passing into red micaceous clay shale.

Fossils were found in the quartzite about half a mile north of Camp 25 on Petermann Creek, and again at two-and a-half-miles north of the same point. Further north still, on the northern half of this great denuded anticline, the fossiliferous horizon in the quartzite was again met with; while still further in the same direction, near Tempe Downs Station, the fossiliferous limestone, on the same horizon as that mentioned above, comes to the surface, and has yielded many fossils.

A vertical section of the fossiliferous beds in Middle Valley at Tempe Downs is as follows:—

	Thickness.
Three bands of fossiliferous limestone, from two to four inches thick, dipping at 80° to the south, separated by sandy clay-slates -	45 feet.
Sandy clay-slate, charged with *Asaphus illarensis*, passing into - -	1·5 ,,
Soft sandstones crowned by a quartzite, which is fossiliferous - -	40 ,,

2. Ooraminna Pass Section.—The Oooraminna Range, which has a breadth of seven miles, is intersected in a north and south direction by a narrow valley excavated to a depth of from 200 to 300 feet. The basal rocks are bluish-grey dense limestones in courses of two to four feet thick, separated by thinner fissile limestones. They strike W. 10° N. and dip from an anticlinal ridge at 9°; a total thickness of forty feet was measured in the limestone series. In distinct conformability there succeed quartzose sandstone and two chief quartzite bands, the uppermost of which forms the chief surface-rock of the range (see Section 8). No fossils were observed, but a hard yellow sandstone forming part of the corresponding arenaceous series in James Range, penetrated in the well-sinking at Deep Well, contained casts of *Isoarca*. Limestones similar to those of the Ooraminna Pass, and readily recognisable by their exceedingly hackled weathered surfaces, form the superstructure of the country from James Range to the southern boundary of the Ordovician area.

The quartzites of the Ooraminna Pass are somewhat irregularly developed, and occasional instances were observed, particularly at Ooraminna Waterhole, of the gradual passage in a horizontal direction from sandstone to quartzite. A remarkable physiographic feature is presented at the south escarpment of the range in the form of four or five tall, wall-like masses of quartzite in close proximity (locally known as Hell Gates). The planes of stratification in the

adjacent sandstones are distinctly traceable, the dip not exceeding 10°. These structures must have resulted from silicification passing downwards along vertical planes of limited width, so that alternations of quartzite and unaltered sandstone occur, and that subsequent denudation has removed the softer intervening material.

3. Red-bank Gorge Section.—A section of the strata exposed in the gorge, through which the Red-bank Creek finds its way through the range, was examined, together with the exposures to the south. The strata here are much disturbed and altered, and the bedding-planes of the quartzite, in which for the most part the gorge has been cut, can only be made out with great difficulty. Further south the quartzite gives place to micaceous clay-slate, the junction line between the two rocks revealing the amount and direction of dip. Bands of much-crushed quartzite and clay-slate, dipping at an angle of 32° N.N.E., alternate with one another as we travel southwards. At the southern extremity of the gorge the quartzite is entirely replaced by micaceous clay-slate, which is in places highly charged with oxide of iron, and some part of which is no doubt identical with the ironstone hill described by Mr. Tietkens (xii., p. 10). Underlying this clay-slate are thick beds of much-disturbed and contorted magnesian limestone containing large concretionary masses of oxide of iron. White masses of magnesite, which have weathered out of the limestone, occur on the surface. Interbedded with this limestone are thin bands of a strongly-laminated yellow micaceous shale. The limestone has been much cracked, and into the usually narrow crevices thus produced anhydrous and hydrous varieties of silica have filtered, forming numerous veins, which intersect the limestone in an irregular manner. Further south the surface of the country is covered by sand, gravel, and river-alluvium of the Davenport and its numerous tributaries.

In the valley of the Davenport, west of Mount Sonder, gneissic granite was observed outcropping at the surface, being in all probability an inlier of the Pre-Cambrian group. In the range through which the Finke River flows (when there is any running water in its channel) quartzite occurs shortly below the junction of the Ormiston and the Davenport, dipping at very high angles to the north. Further south along the Finke Gorge fossiliferous quartzite succeeds, dipping 70° N. 20° E., this being underlain by thinly-bedded and ripple-marked quartzite, and by quartzite with annelide burrows. Below this latter we find silicio-argillaceous limestone passing into quartzite, and further south still there are grey quartzites dipping 66° N. 20° E.

Observations made further to the west in the Horn Valley prove that red fossiliferous limestone underlies the last mentioned rock. South of this last point there is a great thickness of quartzite dipping at high angles to the north. This is overlain unconformably by a thick bed of conglomerate of Post-Ordovician age.

The section in Mereenie Bluff presents the following succession of beds in descending order; the thicknesses are by estimate:—

	Thickness.
Quartzite - - - - - - - - - - - - - -	300 feet.
Yellow friable sandstone - - - - - - - - - - -	300 ,,
Dark brown or purple shales with intercalations in the lower portion of blue, calcareous, arenaceous shales up to 7 feet thick - -	100 ,,
Calcareous shales with many thin limestone-bands, the upper ones with *Isoarca*, the lower ones with *Orthis leviensis* - - - - -	60 ,,
Unseen - - - - - - - - - - - - - - -	?
Quartzite forming the south escarpment of Horn Valley.	

For general stratigraphical features see Section from Mereenie Bluff to Belt Range.

(*f*) *Isolated Portions of Ordovician.*

The most southern isolated mass of Ordovician rocks examined by us, with the possible exception of Ayers Rock and Mount Olga, was a quartzite hill, which Mr. Winnecke named Mount Watt, and which is situated about twenty-four miles west of Engoordina on the Finke. This hill, together with a more elongated mass lying to the north of it, which there was no time to examine, is situated well within the area occupied superficially by rocks of Cretaceous age. From its summit the flat-topped hills, so characteristic of the Cretaceous formation, could be seen on all sides; while immediately surrounding it red sand-hills clothed with *Triodia* formed the prevailing feature, and swept almost up to its base. This hill, which rises to an elevation of 240 feet above the surrounding sand-hills and 1300 feet above sea level (according to Mr. Winnecke's calculation of the altitude of Camp 14 at the foot of the hill), is composed from base to summit of a hard, dense quartzite, with a talus of the same material surrounding its base. The strike of the quartzite varies from N. 50° E. to N. 60° E., and the dip varies in amount from 7° to 10°. The greater part of the quartzite is of a grey colour, but there are a few red ferruginous bands, one about six feet and another fourteen feet from the summit, the latter band having a thickness of twenty-five feet. The rock is much fissured, one set of cracks running nearly parallel with the strike.

Fossils were found in large numbers in this quartzite at and near the summit, but they were all in the form of casts. The lowest point at which they were obtained *in situ* was about twenty feet from the summit. Fragments, however, were found lower, but only in the talus.

Winnall's Ridge and the outcrops between it and George Gill Range.—In the journey from George Gill Range in a S.S.W. direction to Ayers Rock a number of outlying portions of Ordovician strata were met with, surrounded on all sides by red sand-hills. About three-and-a-half miles from Reedy Hole, on the south side of George Gill Range, the eastern extremity of a low sandstone outcrop was passed; at eight miles from the same point a low sandstone ridge with an E. and W. strike was crossed; and at eleven miles our course led us past the eastern extremity of a low sandstone range, striking in a W.N.W. and E.S.E. direction, the sandstone of which had a dip of about 10° to the south. All these outcrops of Ordovician strata are separated from one another, and from those about to be mentioned, by red sand-hills, which entirely conceal from view the rocks which underlie them. At twenty-four miles from Reedy Hole a low sandstone range, striking in a W. 35° N. direction was passed, and at thirty-one miles we journeyed within four miles of an elevated, isolated hill lying W.N.W. of our track.

The last and most important development of Ordovician rocks observed on the trip to Ayers Rock was Winnall's Ridge, situated thirty-nine miles S.S.W. of Reedy Hole, and nine miles north of Lake Amadeus at the point where we crossed it, generally known as "Gosse's Crossing." This ridge rises to an elevation of 200 feet at the eastern end, where it was examined, and at the western end it appeared to rise at least 100 feet higher. Its altitude above sea-level is probably from 1700 to 1800 feet. The strike of the ridge is W. 15° N., and its length about three miles, its width at the base varing from 200 yards to a quarter of a mile. It is composed of a dense grey quartzite, which on the northern face is observed to dip southerly at about 25°, and on the south face to dip northerly at about the same angle. The rock thus forms a synclinal trough, which fact is readily apparent when the ridge is viewed in the direction of the strike. No fossils were found in this quartzite.

IV.—Post-Ordovician Conglomerate.

The earliest reference to this formation is by Giles (iv., p. 17), and was later traced by Chewings* west of Ellery's Creek to the head of Rudall's Creek.

* The Sources of the Finke River, by Chas. Chewings, Adelaide, 1886, pp. 23 and 34.

In 1891 Mr. Chewings (xi., p. 252), classed this conglomerate with "Mudstone and the Ooraminna Sandstone" as Devonian (?) The Ooraminna Sandstone, as mentioned elsewhere, we believe to belong to the Ordovician System, whereas it is quite certain that the conglomerate must be younger.

During a trip from the Lutheran Mission Station, on the Finke, northwards *via* Ellery Creek to the McDonnell Ranges, an excellent section of this conglomerate was examined. Four miles N. 60° E. from the Mission Station loose pebbles, that did not appear to be derived from a recent river gravel, were observed on the surface of low circular hills. Two miles further north a well had been sunk in micaceous conglomeratic sandstone. Twelve miles N. 56° E. from the Mission Station the track crossed Ellery Creek, and here the conglomeratic sandstone was first seen *in situ*, its dip being 15° nearly due south. Further to the N.E. the conglomerate, alternating with pebbly sandstone, dips at 14° S.S.W., the former being very coarse in places, some of the pebbles being as much as one to two feet in diameter. Here some pebbles were collected, which proved on examination to have been derived from granites, gneisses and schists of various kinds, with also a few quartzite pebbles. Northwards the angle of inclination of the beds gradually increases, as the following figures show:—Dip where first observed (at "Sheep Camp"), 15°; at 3 miles, 20°; at $4\frac{3}{4}$, 30°; at 6, 45°; at $6\frac{3}{4}$, 49°; at $7\frac{3}{4}$, 60°; at 8, 60°.

At eight miles from the locality, where the conglomerate was first observed, the dip had gradually increased to 60°; it was at this place that pebbles of red limestone were obtained from the conglomerate, which contained the following Ordovician fossils:—*Actinoceras tatei*, *Palæarca wattii*, *Orthis dichotomalis*, fragments of trilobites. Underlying this conglomerate is sandstone dipping 61° south, followed by quartzites and limestones belonging to the Ordovician System, which gradually increase in dip as they are traced to the north. An examination of the pebbles, obtained from the conglomerate, reveals the fact that the lowest strata which of course were deposited first, are almost entirely composed of fragments derived from the Ordovician strata, such as sandstones, limestones and quartzites, while the topmost layers are very largely made up of pebbles derived from the Pre-Cambrian rocks. These phenomena show that, when the lowest beds were being deposited the rivers were eroding their valleys out of Ordovician strata, but that, when the uppermost beds were being laid down, the erosion had extended to the underlying Pre-Cambrian rocks. The total thickness of this conglomerate and conglomeratic sandstone cannot be less than 7000 feet.

V.—Upper Cretaceous.

General Characters.—The supter-structure of the lowest levels around Lake Eyre has long been known to be argillaceous, and to contain marine fossils, as at Mount Margaret, Primrose Springs, and Dalhousie. The fauna was at first referred to the Jurassic period, but has in late years been recognised as contemporaneous with that of the Rolling Downs series of Queensland. This formation is surmounted by a hard flinty quartzite or chalcedonised sandstone, varying up to fifty feet in thickness, which forms the topmost bed of the table-land country, and will be herein referred to as the Desert Sandstone. Messrs. Jack and Etheridge, "Geology of Queensland," (p. 390), assign the Rolling Downs series to the Lower Cretaceous epoch; but the facies of the fauna is more akin to that of the European Upper Cretaceous, while the palæontological differences between it and the Desert Sandstone are too slight to justify the application of the terms Lower and Upper to them respectively, therefore we substitute Upper Cretaceous and Supra-Cretaceous in their place.

Artesian bores around the south and west sides of Lake Eyre have proved the Upper Cretaceous to be essentially argillaceous. By the courtesy of the Conservator of Water, we have had the privilege of inspecting the bore material from the Oodnadatta bore and publishing whatever may be desirable relating thereto; the boring was near completion on our return to that place. The site of the bore is approximately at the same level as the railway station, namely, 397 feet above the sea; the bore was discontinued at a depth of 1571 feet, where a good supply of water was tapped. The whole thickness is essentially argillaceous, varying from clay, shale, to marly clay, intercalated with which are thin argillaceous limestones and some sand-beds; these latter occur at various horizons, and the chief supply of water was obtained in the basal sands of the section. Thus the general character of the strata passed through is like that of other bore sections in the Lake Eyre basin. The deeper seated shales and limestones are sparingly fossiliferous, and at Oodnadatta the only fossil-record is at 1070 feet in depth; whilst a fairly rich fauna has been collected from the outcrop of the topmost limestone at the various localities previously named. Up to the present no distinctive rock-formation or fossil-zone has been recognised by which it would be possible to correlate one bore section with another, and so to arrive at some knowledge of the physical structure of the basin and the probable source of its artesian waters.

The Oodnadatta bore-section is continued above the surface in the low bluffs to the northward of that township by a limited thickness of argillaceous strata,

sometimes highly indurated, as at Storm Creek, surmounted by the Desert Sandstone. The prevailing argillaceous formation in the southern area of the Cretaceous basin continues north to Dalhousie Springs, where fossils occur, as described by East* (viii.). To Mr. Byrne, in charge of the telegraph office at Charlotte Waters, the writers owe the possession of examples of *Crioceras australis* and a coral, preserved in chalcedony, collected in the neighbourhood of Charlotte Waters; but Mr. East obtained specimens of *Lingula subovalis* in a glauconitic clay-stone at Mount Daniel, which is about twenty miles north of Charlotte Waters, and the most northern occurrence of a marine fossil of Upper Cretaceous age within the Lake Eyre basin.

Mount Daniel is 1330 feet above sea level, and its geological structure in descending order is as follows:—Desert sandstone, 18 feet; purple and grey shale, 22 feet; red shale, 40 feet; yellow and grey shale, thickness unknown. As we go north from Mount Daniel, and towards the Upper Cretaceous shore-line, the shales and clays appear to be replaced by sandstone, which is only what might be expected, namely, that the rounded sand grains would be deposited nearer the shore, whilst the lamellæ of clay were carried towards what is now the centre of the basin. In illustration of this change in sedimentation the following sections are introduced:—

Hill, two miles from Goyder River.—(1), Highly ferruginous grit, 15 feet; (2), ferruginous sandstone, 65 feet; (3), white friable sandstone, 20 feet; (4), ferruginous grit, sandstone and cherty shales, 20 feet; (5), red iron-stained sandstone, micaceous, and in places gritty, 60 feet; (6), friable white micaceous sandstone containing a moderate quantity of salt, which effloresces out of it, 20 feet; total thickness, 200 feet.

Hill, between Goyder River and Lilla Creek.—(1), Ironstone, sandstone and shale cemented by iron, 10 feet; (2), argillaceous sandstone, 1 foot; (3), ferruginous sandstone, 30 feet; (4), coarse grit, 3 feet; (5), white friable sandstone, 100 feet; total thickness, 144 feet.

Mount Musgrave.—(1), Desert sandstone, 10 feet; (2), white friable sandstone in beds, which show a slight northerly dip, about 200 feet; (3), ferruginous, very micaceous, clayey sandstone, with thin bands of white sandstone, about 200 feet.

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* The following species from this locality have been under observation:—*Natica variabilis*, *Maccoyella reflecta*, *Modiola inflata*, *Cardium*, sp.

Johnston's Range.—(1), Desert sandstone, 6 to 8 feet; (2), soft white felspathic sandstone, 25 feet; (3), more indurated red sandstone, 25 feet; (4), soft grey argillaceous sandstone, 70 feet. The dip of the beds is about 6° nearly due south. Giles describes the north escarpment of this line of elevation as exhibiting successive planes of water-erosion, but his "water lines" are simply the effect of alternating bands of variously-coloured rocks, seemingly horizontally bedded, as viewed on the line of strike (east and west, which is also the bearing of the escarpment).

The main mass of the Upper Cretaceous reaches as far north as the latitude of Engoordina, as at Mount Squires, near there, and Johnston's Range, further west. North of this latitude much of the country is buried beneath sandhills and river drift. Bluffs along the margin of the River Hugh, below Alice Well, and to its junction with the Finke, are composed of unaltered sandstone, and they occasionally occur northward to about seven miles south of Mount Burrell. Of these outliers Chambers' Pillar is the most conspicuous. In an amphitheatre-like depression in the Ordovician limestones, through which flows Alice Creek, there occurs a micaceous shale as brought to light by a well sinking, which is probably of Upper Cretaceous age, and if so, then the most northerly occurrence in this part of Australia. For the most part, the stratification of the Upper Cretaceous is apparently horizontal, though slight undulations of far-reaching extension prevail in the northern area occupied by these rocks.

Relation to Artesian Waters.—It has generally been held that the source of supply of the Natural Artesian Wells on the west side of Lake Eyre was derived from tropical rains in Queensland absorbed by Cretaceous outcrops, and that the issue of these waters was along the line of junction of the Cretaceous water-bearing beds with the Palæozoic rocks on the west margin of Lake Eyre. But the now-ascertained far-northerly extension of the Cretaceous rocks, and the replacement of the prevailing argillaceous condition by sandy strata towards the northern boundary make it probable that the source is, after all, of local origin. Thus, the Finke River from Henbury to Crown Point flows approximately along the junction of the Cretaceous arenaceous beds and the impervious Ordovician limestones; so also do the Goyder and Lilla Creeks, particularly towards their sources. Moreover the Cretaceous beds have in the main a slight southerly inclination. It is, therefore, highly probable that they do absorb some of the flood-waters of those river-channels, and conduct them to considerable depths in the depressed area margining Lake Eyre; whilst in no instance do the subterranean waters issue at the surface at a level so high as that of their conjectural intake. The phenomenon

of extinct mound-springs, as at Dalhousie, may be explained by the circumstance of a diminished supply, in other words that the level of saturation has fallen below the level of discharge as a consequence of the desiccation of the climate since Pliocene times.

VI.—Desert Sandstone (Supra-Cretaceous).

General Characters.—The greatest thickness presented by this formation, as observed at Crown Point, was estimated at fifty feet; it consists of three distinct beds of about equal thickness. The topmost band is a breccia of Desert Sandstone fragments cemented by secondary hydrated quartz; the same phenomenon was noted at Henbury on the Finke River and on the hill-tops about Storm Creek. The other bands present the prevailing characteristics of the Desert Sandstone, which is composed of sharp grains of glassy quartz, varying much in size, cemented by opaque-white highly siliceous matter and more or less stained red by oxide of iron.

No evidence of unconformability between Upper Cretaceous and Desert Sandstone was observable between Oodnadatta and the northern confines of the Cretaceous area, though there is some reason for the opinion the latter overlaps the former. With one single exception the Desert Sandstone reposes on the Upper Cretaceous, but at Henbury a few small knolls of Desert Sandstone repose on Ordovician limestone. The base of the Desert Sandstone is never conglomeratic, though pebbles of quartz and angular pieces of indurated shale were found at a depth of ten feet below the summit of Mount Daniel.

*Palæontological Features and Correlation.**—Hitherto no fossils have been recognised in the Desert Sandstone within the area traversed, if we expect obscure impressions probably of twigs or wood. But the topmost stratum of the table-topped hills, to the south of Oodnadatta and extending into the basins of Lakes Torrens and Gairdner, which has the structural peculiarities of the Desert Sandstone, except that it is rudely fissile, contains plant-impressions. And in the south-east part of the Lake Eyre basin extending to Lake Frome a similar flora occurs in carbonaceous strata, which at the latter locality is associated with marine fossils of Cretaceous age. A more particular account of these discoveries is now submitted:—

* The substance of this sub-chapter, under the title of "Plant-Bearing Strata in Central Australia," was read by one of us before the Royal Society, S.A., 2nd July, 1889, but the publication of it was deferred pending the result of the bores in the Leigh's Creek coalfield, which have however no connection with the subject now to be dealt with.

(1) Area, west of Lakes Eyres and Torrens.

William Springs (123 miles south from Oodnadatta), a well defined impression of a *Cinnamomum* leaf on the surface of a characteristic piece of chalcedonised Desert Sandstone was presented to the S.A. Museum in 1872.

Bottle Hill and Andamooka (west side of Lake Torrens).—Several slabs of flaggy quartzites, rich in leaf impressions, were obtained at these localities by Mr. W. L. R. Gipps in 1876, and presented by him to the University Museum at Adelaide. Similar specimens from the former locality, collected by Mr. Wentworth Hardy in 1883, were donated to the same institution.

Lake Gairdner and the Elizabeth River.—In 1883 Mr. Clement Sabine transmitted to the University Museum similar fissile quartzites, showing abundant plant-remains on their surfaces, from these localities. Accompanying the above was a block of an excessively fine earthy sandstone, without bedding planes, con-the casts of the following determinable species of marine bivalves :—*Maccoyella barklyi*, *Cyprina clarkei*, and *Nucula quadrata*. The stone was obtained from a quarry situated at "seven miles S.W. from Mount Paisley, say long. 135° 45′ and lat. 30° 15″." These facts establish the presence of marine Cretaceous beds and phytiferous strata in the same area ; and though there is no direct evidence of the superposition of the latter, yet it may assumed to be so from the circumstance that a similar, if not identical, quartzite forms the surface-bed over much of the surrounding country and imparts to the table-topped outliers and low ranges their characteristic outline.

Arcoona (west of Andamooka).—Similar phytiferous quartzites were presented by the Government Geologist, Mr. H. Y. L. Brown, in 1888, to the Adelaide University.

(2) Area south-east of Lake Eyre, *between Lake Frome and the Barrier Ranges* In well-sinkings near Lake Frome (a south-eastern extension formerly of Lake Eyre), sandstones and clays, blackened with coal-smut, were passed through. From the information and specimens furnished by the Conservator of Water for the South Australian Government, Professor Tate reported (Trans. Roy. Soc. S. Aust., vol. v., p. 98, 1882) that exogenous leaves, all of one species, were abundant and associated with casts of marine shells ; the period assigned was Miocene. On reconsideration of the evidences in the light of additional and collateral information, he is of opinion that the marine fossils are of Cretaceous age, as the known distribution of the marine Eocene is incompatible with its occurrence at this locality, whilst the Cretaceous age conforms with the area over which undoubted marine beds are known to cover. The marine fossils indicate the presence of four

genera of bivalves; but as they are represented by casts, specific references are unreliable. They are *Nucula quadrata* (?), *Aucella* sp., *Pecten* sp., genus uncertain, comparable with fig. 16, t. 24, in Jack and Etheridge's Geol. of Queensland. The leaves belong to *Magnolia Brownii.*

Wyeculuna (on the River Clayton).—Plant-bearing beds have been described by Mr. H. Y. L. Brown as occurring at this locality. He referred them at first to the period of deposition of the Leigh Creek coalfield—that is Jurassic, which opinion has since been amended "to probably of Tertiary age."* Among the vegetable remains collected at this place, I recognise leaf-impressions as belonging to *Alnus Muelleri* and *Quercus*, spp.

The association of land-plants and marine fossils is not inconsistent with the Desert Sandstone age of the Lake Frome beds, as in the extreme north-east of the vast Cretaceous deposits in Queensland, coaly layers and marine sediments are interstratified. Hitherto, the only plant-remains descriptively known from undoubted Desert Sandstone are the ferns *Didymosurus? gleichenioides* and *Glossopteris* sp.;† neither one nor the other occurs in beds of corresponding age in Central Australia. Here all the plant species are represented by leaves of exogens, and of these the following, among many others, are referable to described species:—

Magnolia Brownii *Ett.*	Lake Frome.
Cinnamomum sp.	William Creek.
Apocynophyllum Mackinlayi, *Ett.*	Arcoona.
Bombax Sturtii, *Ett.*	Elizabeth R.
Eucalyptus Diemenii, *Ett.*	Arcoona.
Eucalyptus Mitchellii, *Ett.*	Elizabeth R.
Banksia pregrandis, n.sp.	Bottle Hill.
Quercus Greyi, *Ett.*	Elizabeth R. Arcoona. Wyeculuna.
Quercus Wilkinsoni, *Ett.*	Wyeculuna.
Alnus Muelleri, *Ett.*	Wyeculuna.

The flora here indicated is analogous with that at Vegetable Creek and Dalton, described by Baron von Ettingshausen,‡ and on palæontologic ground has been regarded by him as Eocene. The same type of flora is preserved at various

* Parl. Paper, No. 141, 1892, p. 5.

† Jack and Etheridge, Geol. Queensld., pp. 557-559, 1892.

‡ "Contributions to the Tertiary Flora of Australia." Mem. Geol. Surv. N. S. Wales, 1888.

localities in Victoria, the age of which is considered by McCoy to be Miocene; but it has, however, been shown that the Victorian occurrences are below marine Eocene, and this accords well with the general fact that wherever the base of the marine Eocene is reached, lacustrine and plant-bearing beds succeed in depth. Beds of this age in New Zealand have been called Cretaceo-Eocene by Hector.

The Vegetable Creek and Dalton beds do not come in contact or in near location to Cretaceous; and the marine Tertiaries are absent in New South Wales, as well as in the country occupied by the Desert Sandstone.

We have, thus, a late Cretaceous deposit and an infra-Eocene one, containing the same type of vegetation, several species being actually common to the two, which, if not coeval, must be coterminous; it was because of such considerations that one of us* had suggested the probability of a palæontological overlap between Cretaceous and Eocene in Australia.

The fact that the Desert Sandstone of Queensland has not yeielded this type of vegetation is no argument against the contemporaneity of the phytiferous beds of Lakes Eyre, Torrens, etc. The same type of vegetation is common to the Laramie-Cretaceous of North America and the Palæogene of Europe; and the question of age of the Australian equivalents may be answered in much the same way as was done in respect of their contemporaries in the northern hemisphere. The Desert Sandstone of Central Australia by its attachment to the Upper Cretaceous, and by the occurrence of marine Mollusca of Cretaceous age (at Lake Frome well-sinkings) must be regarded as coeval with the Desert Sandstone of Queensland, which, by its intercalated marine sediments is proved to be Cretaceous; though separated unconformably from the Rolling Downs series (Upper Cretaceous). The phytiferous beds, which underlie marine Eocene in Victoria and South Australia and are conformable with them, may conveniently be considered Pre-Eocene.

VII.—Post-Cretaceous Phenomena.

Age of Secondary Silicification.—That the silicification of the Desert Sandstone was long subsequent to the period of deposition of the original matrix is evident from the following facts:—

1. The uppermost stratum is a breccia, impregnated and cemented by hydrated silica. Every exhibition of this condition is suggestive of crushing or shattering of the rock *in situ*, without any actual displacement of the fragments.

* Presidential Address, Aust. Assoc. Adv. Science, 1893, p. 35.

2. Denudation of the Upper Cretaceous and Desert Sandstone was considerable, both in depth and superficial extent, before silicification supervened. Thus the marly clays at Dalhousie become porcelainised as they are traced northward; and in the neighbourhood of Charlotte Waters a white hard kaolin, which is, however, not so hard as to resist the knife, is at one spot converted into a porcelain of a hardness approaching that of quartz. It was from associated beds that Mr. Byrne obtained silicified casts of *Crioceras* and a coral. In every example of silicification of the sediments of Upper Cretaceous age there is no covering bed, and when the Desert Sandstone is present the alteration is limited to that formation. It may therefore be inferred that denudation of the Cretaceous plateau preceded the process of silicification, which, acting from above downwards, affected whatever sediment chanced to be at the surface. The texture of the original Desert Sandstone permitted doubtlessly greater penetration in depth of the silicifying agent than was possible in the case of the argillaceous deposits. In the former the alteration is by infiltration into the interstices of the original coarse-grained sandstone, producing a rock which simulates a porphyrite in texture—a clear vitreo-resinous colloid quartz, compacting sharp quartzose sand-grains. In the latter the change seems mainly to be that of substitution.

Area Affected by Secondary Silicification.—We have not the data to deliminate the area over which this chemical alteration has taken place, but that it is vast may be inferred from the following occurrences:—

Throughout the Lake Torrens basin and the western section of the Lake Eyre basin the Desert Sandstone is chalcedonised, extending to the most northern of its outliers in the vicinity of Henbury. The Ordovician limestones about the sources of Alice Creek seem also to have been subjected to the same influences, as along the bedding planes of the somewhat fissile limestones chalcedonic substitution has taken place for a thickness of an inch or so. An extreme phase of this structural alteration is the development of noble opal in the Cretaceous rocks at White Cliffs, about sixty miles in a north-westerly direction from Wilcannia, and thence passing into South Australia near Cooper Creek. Mr. Anderson* writes that the chief source of the opal is the Desert Sandstone, in which it occurs in three following positions:—

1st. Disseminated in minute fragments throughout the substance of the rock.

2nd. Coating the joints and fractures.

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* Records Geol. Surv. N.S.W., vol. iii., p. 30, 1892.

3rd. Occurring irregularly as definitely-shaped pieces, which have resulted from the replacement of fragments of fossil wood, shells, etc.

Cotemporaneous phenomena.—The phenomena of silicification of the Cretaceous deposits is most fully displayed between the Stevenson River and Charlotte Waters, and here is the metropolis of obsidian bombs and unrolled agates. Bombs and agates occur widely dispersed over the Cretaceous area in Central Australia, but we are not aware if any other locality has yielded them in their pristine condition, the former are most frequently found in an eroded state, and the latter in a fragmentary condition, and more or less rolled. The agates which abound between Blood Creek and the River Stevenson, range from the size of one's fist to that of one's head, exhibit a black somewhat scoriaceous exterior and in appearance resemble those obtained in volcanic scoriæ.

Origin of the Silicification.—Mr. East (viii., p. 52) attributes the change from a sandy formation to a porcelainised sandstone to immersion in silicated waters, derived from the decomposition of the metamorphic rocks of the McDonnell Range, which have wholly evaporated. That the phenomenon of silicification implies precipitation from solution cannot be denied, but Mr. East's view limits the operation to the final evaporation of the lacustrine waters in which the Desert Sandstone was deposited; whereas we have endeavoured to prove that considerable denudation had taken place before silicification could have happened, whilst the accompanying phenomena, viz., the formation of agates, and obsidian bombs and Desert Sandstone breccia, seem to demand a common origin. It must be conceded that the process of silicification has stopped; that the artesian waters of the Cretaceous basin do not, and probably never did, possess silicifying properties. Under the circumstances we hope to be pardoned for speculating upon the origin of this silicification, which shall, at the same time, be in unison with the requirements to satisfy that of the attendant phenomena.

In the first place the occurrence of the obsidian bombs and agates on the Desert Sandstone plateaus and their slopes could not have been transported there by water, unless in the form of ice (an hypothesis incompatible with the co-ordinate features). The origin of the Desert Sandstone breccia was certainly not due to fracture of the original bed by failure of support arising from denuding action, but might have been caused by a lava-flow or the deposition of highly heated volcanic ashes when saturated with water. The obsidian bombs demand volcanic action, and agates are not infrequently associated with volcanic ejectamenta; whilst the silicates of the ash-beds or lava under chemical action would furnish silicated waters as a source of the chalcedonising action on the underlying rock-surfaces,

The development of agates within the volcanic material was only another phase of siliceous precipitation. Of this suppositious volcanic formation all that remains are the agates and the obsidian bombs. The theory seems wild in the extreme because of the wide-spread silicification, and the absence over its area of any traces of actual volcanic outbursts; nevertheless, no other explanation accounting for the several phenomena appears to us admissible.

VIII.—Tertiary.

Excepting the silt deposits of the present water-ways and the wide-spread sand-plains, the only Tertiary deposits of any significance are those which indicate a former water-flow of vaster volumes than at present. These signs are chiefly in the form of gravels, more or less consolidated, through which the present water-channels have cut their way, or in the form of terraces margining the valley-plains through which now flow relatively diminutive creeks. These facts demonstrate that high pluvial conditions once prevailed; and, in consequence, perennial flows in the river-channels of this region were maintained, which, discharging into Lake Eyre, and supplemented by an Artesian supply in and around it, produced an inland sea of fresh water, inhabited by alligators *(Pallimnarchus pollens)* and turtles, and on its marshy margin dwelt *Diprotodon* and its fossil associates. Inferentially the date of formation of these gravels and river-terraces is coeval with the existence of *Diprotodon*, whose extinction was due to those physical causes which destroyed its habitats, and gave Central Australia its present rigorously dry climate. The marsupial life of this period, on comparison with that which replaced it, indicates a high antiquity in the number of extinct genera, and the very high percentage of extinct species, so much so, that the only applicable time-term is (NEWER) PLIOCENE, and not Pleistocene or Post-Tertiary as employed by some writers.

RIVER GRAVELS.—The River Goyder, where examined by us, flows between low cliffs of river detritus, and low mounds extending far back from the existing channel, are composed of the same material. A section at about two miles east from the telegraph-crossing comprises from above downwards:—Sandstones somewhat evenly bedded, 5 feet; conglomerate of subangular pebbles of quartzite and Desert Sandstone, 1 foot; friable white sandstone, current-bedded, with a coarse sharp grit in the medial part, 20 feet; total, 26 feet.

The south bank of the Finke River, at Henbury, is composed of gravel 20 feet high.

Resting against the escarpment on the north side of Crown Point is a well-defined shingle-beach, rising to an elevation of, at least, fifty feet above the Finke Channel; whilst well-rounded pebbles reach up to the base of the Desert Sandstone on Crown Point, and much gravel is scattered over the low-level country for several miles northward. East* noted that the channel of the Finke at this place is strewn with large boulders of red granite, some weighing about a quarter of a ton.

It would appear that prior to the formation of Cunningham Gap (the break in the escarpment), the waters of the Finke were impounded to form an extensive lake, during which the shingle collected and reached higher and higher levels as the lake-water gained depth. The rock-structure of the gorge, as seen in Crown Point, consists in descending order of Desert Sandstone, about fifty feet, resting nearly horizontally on false-bedded, friable, felspathic sandstone and purple, hard, sandy clays. The water-level of the lake reached as high as the base of the Desert Sandstone, and an easy drainage was presented at its junction with the underlying beds, which in themselves especially, also because of the southerly dip, could not offer much resistance to the passage of water. The liberation of the impounded water was, in the first instance, brought about in all probability by the undermining of the coping of Desert Sandstone and its final removal. The irruption of the water was at one stage probably sudden, as a rush of detritus was piled up in confusion to form the low cliffs bordering the Finke at a distance of four miles away.

Yellow Cliff, at the south-east bend of the Finke, near Crown Point Head Station, which is about fifty feet high, consists of:—Yellow and buff sandstone, strongly false-bedded near the top, intersected by vertical joints filled with limonite, enclosing pebbles of Desert Sandstone and quartzite ranging from small gravel to $2\frac{1}{2} \times 4\frac{1}{2}$ inches, occasionally two feet cube; the pebbles are somewhat rounded and smoothed, many of them are standing on edge. At the east end of this bluff the sandstone is very tumultously-bedded, and in its basal part contains a conglomerate of about four feet thick.

On the banks of Adminga Creek there is a thickness of thirty feet of consolidated river-gravel, consisting of alternating bands of coarse and fine material. The pebbles, for the most part, consist of Desert Sandstone, ironstone, and common opal, all of local origin.

River Terraces.—The best exemplification of this feature is in the valley of Alice Creek near its junction with the River Hugh. Alice Creek is shallow, and

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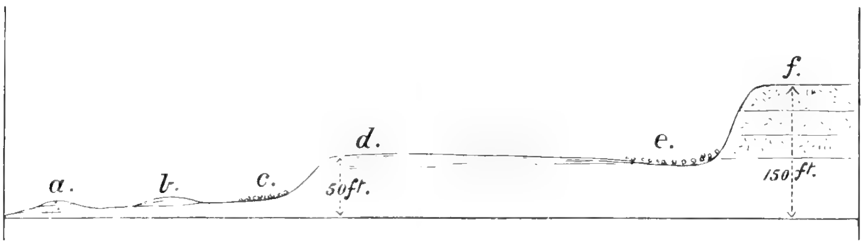
* (viii.), p. 44.

about ten yards wide; it meanders through a valley-plain composed of fine silt; within about three miles from its junction with the Hugh, the valley-plain is seen to be bounded on each side by a terrace, at first about half-a-mile apart, finally converging to less than a quarter of a mile. The terrace is about thirty feet high, and consists of river-gravels resting, near the base, on white sand-rock.

LACUSTRINE FOSSIL DEPOSIT.—The extensive development of travertine around the artesian spring at Dalhousie Head Station, reaching to higher elevations than the present issue of water, and at one spot containing fossils of a fresh-water habitus, points to the probability of the former existence of a considerable lacustrine area. The details of the section are as follows:—



(*a*) Fossiliferous rock, exposure about six feet in diameter.

(*b*) Mound round present springs about ten feet high and 300 feet in diameter. Water slightly saline and warm. Black peaty soil surrounding mouth.

(*c*) Débris from (*d*) travertine deposit.

(*d*) Compact travertine extending for distance of 300 yards.

(*e*) Fifty feet above *c*. Plain red sand loam with loose subangular blocks of Desert Sandstone ("gibbers").

(*f*) Desert Sandstone rising from eighty to 100 feet above *e*.

The fossiliferous rock is a gypsiferous tuff, copiously charged with the shells of *Melania venustula*, Brot., *M. lutosa*, Gould, *M. balonnensis*, Conrad, *Bithinia australis*, Tryon, and *Corbicula sublævigata*, E. A. Smith. No molluscs were found in the dam conserving the outflow from the artesian spring, and none are existent, so far as we know, for many miles around. All the species in the fossiliferous rock are living. Of these *Melania venustula*, *Bithinia australis*, and *Corbicula sublævigata* were hitherto unknown for South Australia till discovered by the Expedition. *Bithinia australis* was taken alive in the River Neales and Storm Creek, near Oodnadatta; *Melania venustula* and *Corbicula sublævigata* were found as dead shells in the channel of the Finke at Crown Point. *Melania lutosa*, as a recent shell, is known only from Fitzroy Island and Cardwell, N.E. Australia.

EXPLANATION OF PLATES.

INDEX TO SIGNS ON THE SECTIONS.

Pre-Cambrian—

α. gneiss.

β. mica-schists.

γ. quartzite.

Eruptive Dykes (granite, etc). *x*.

Ordovician—

a. quartzite.

b. Sandstone.

c. Dolomite.

d. Fossiliferous Limestone.

e. clay slate.

f. Micaceous Slates.

g. Mudstone with cubes.

Post-Ordovician Conglomerates. *o.*

Recent alluvium. ∨

(Figures 3, 8, 9 and 10 drawn by R. Tate; Figures 1, 2, 4, 5, 6 and 7 drawn by J. A. Watt).

PLATE I.

Fig. 1.—Section across McDonnell Ranges in the meridian of Ellery Creek.

Vertical scale - - - - 2000 feet to 1 inch.
Horizontal scale - - - 2 miles to 1 inch.

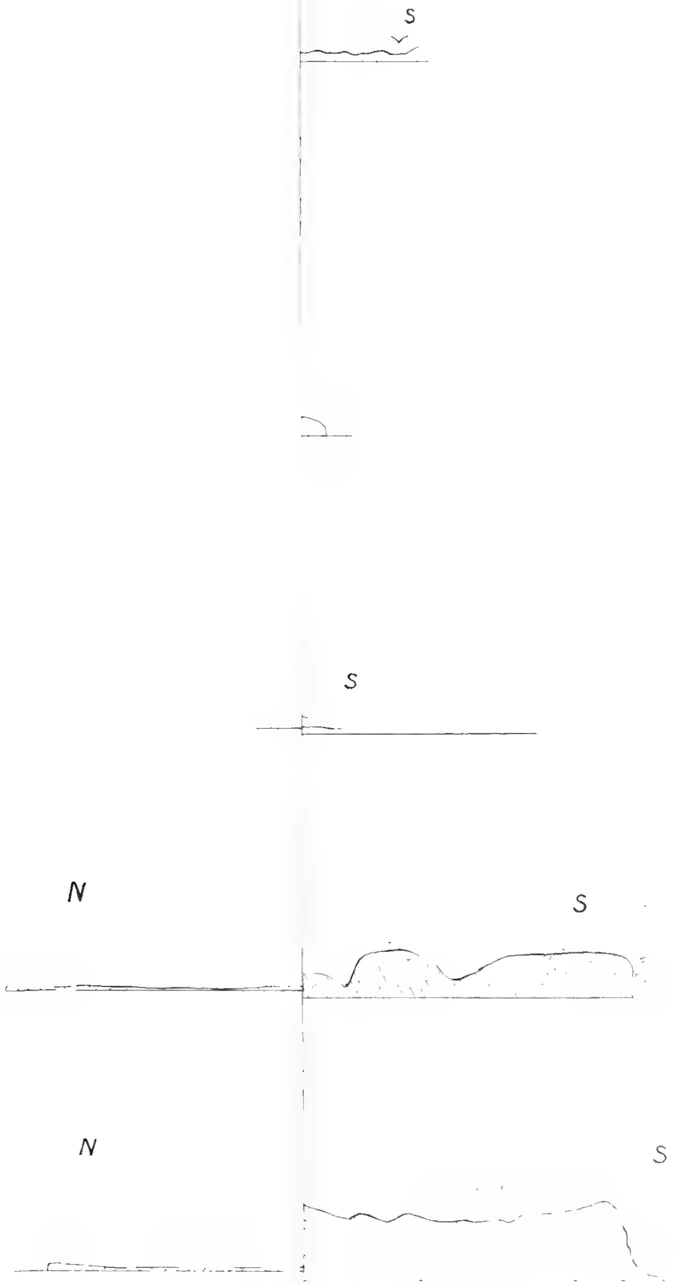
„ 2.—Section across South McDonnell Range, near Heavitree Gap.

Vertical scale - - - - 1000 feet to 1 inch.
Horizontal scale - - - 800 yards to 1 inch.

„ 3.—Belt Range seen from the south, showing Ordovician sandstone and quartzite resting unconformably on Pre-Cambrian gneiss and mica-schist.

„ 4.—Section of Ordovician Strata north of George Gill Range.

Horizontal scale - - - 1 mile to the inch.
Vertical scale - - - 500 feet to the inch.



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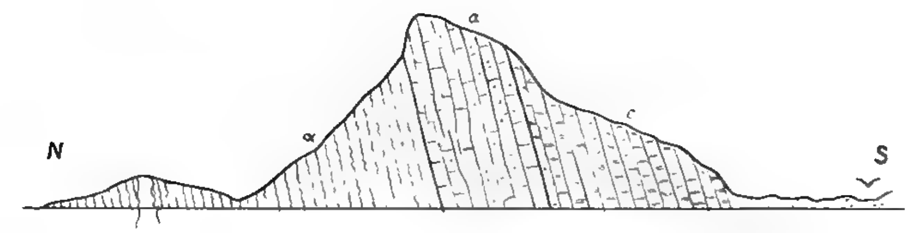


Fig 2

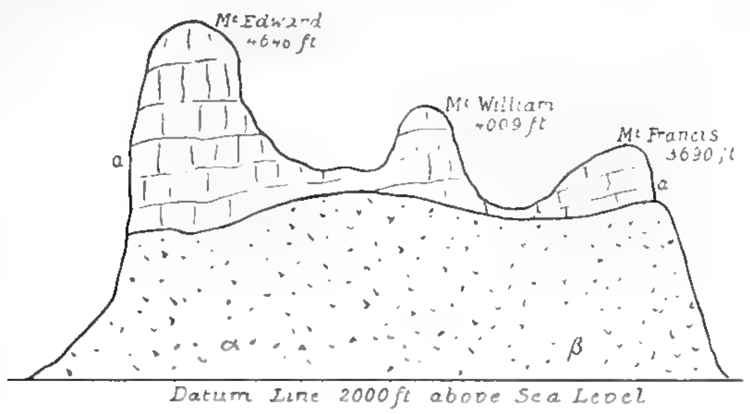


Fig. 3.

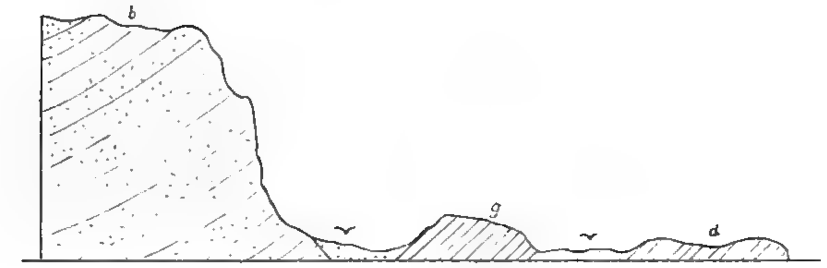


Fig 4

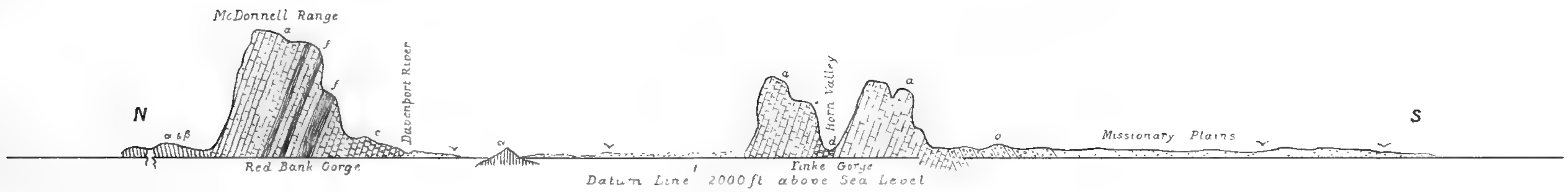


Fig 5

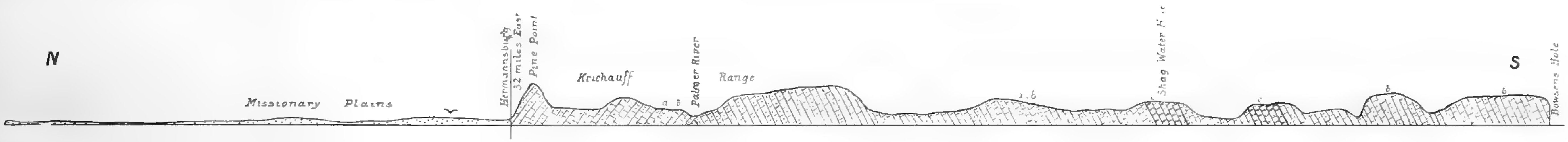


Fig 6.

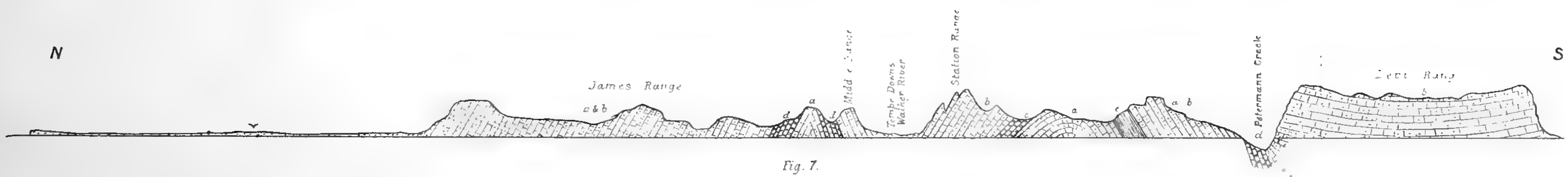


Fig. 7.

R. Wendel lith Melb
Troedel & Co Print

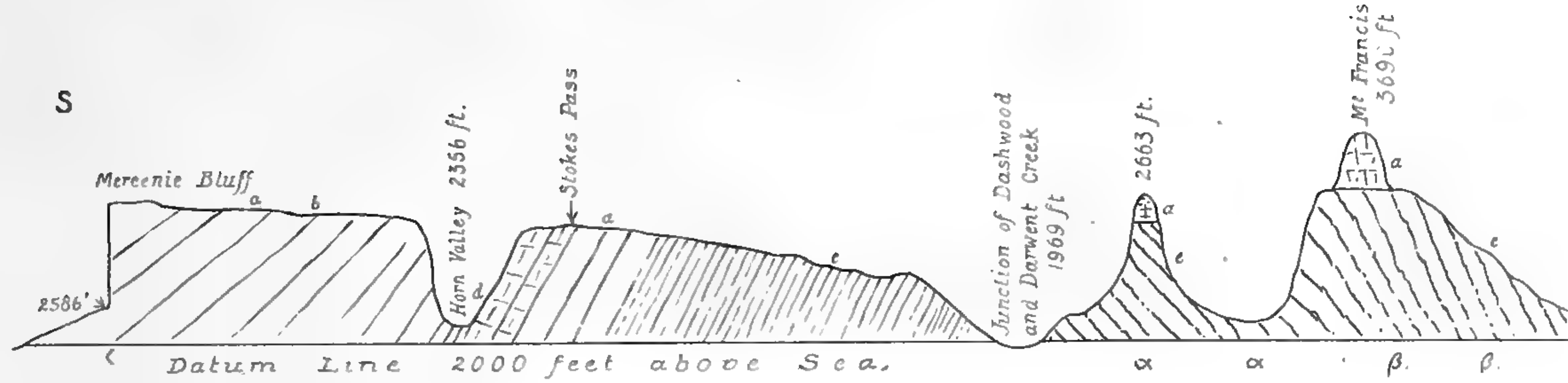
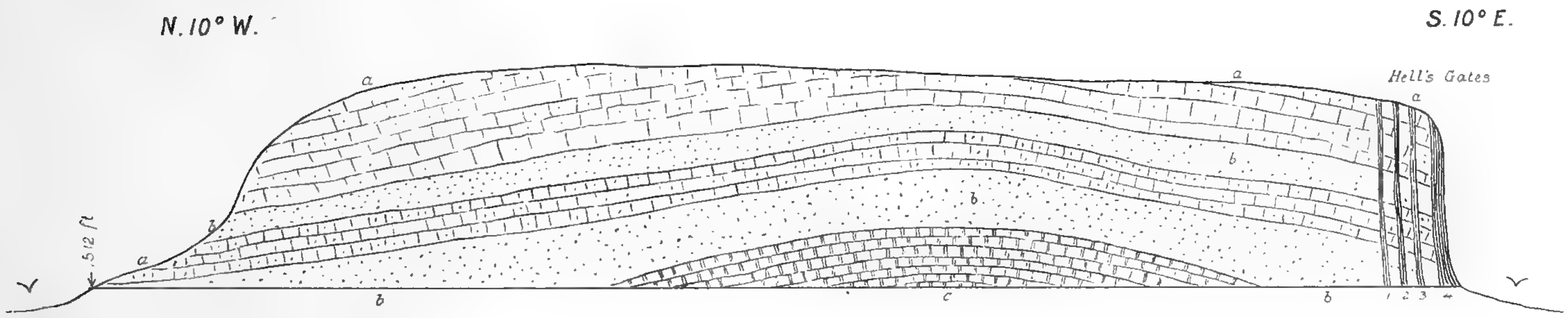


Fig 10



1. 2. 3. 4. Wall-like Masses of Quartzites

Fig. 8

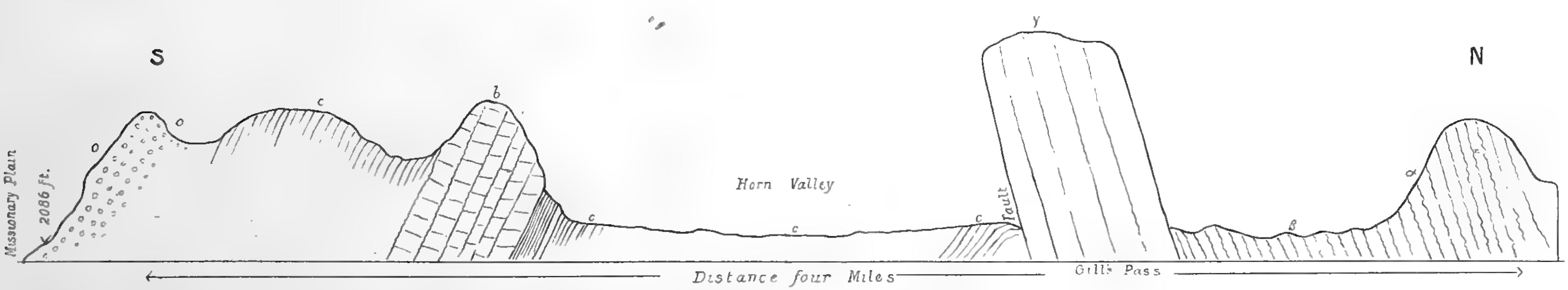


Fig 9

R. Wendel lith. Melb.

Troedel & Co Print

Fig. 5, 6 and 7.—Section from the McDonnell Ranges in the north to Levi Range in the south.

Horizontal scale - - - 2 miles to the inch.
Vertical scale - - - 1000 feet to the inch.

„ 5.—Section across the McDonnell Range to the Missionary Plains.

„ 6.—Section across Missionary Plains and the Krichauff Range.

„ 7.—Section across James Range and Levi Range.

Plate II.

„ 8.—Section through Ooraminna Pass.

Horizontal scale - - - 3 inches to 4 miles.
Vertical scale - - - ½ inch to 100 feet.

„ 9.—Section through Gill's Pass.

Horizontal distance - - 4 miles.

„ 10.—Section from Mereenie Bluff to Belt Range.

Horizontal distance - - - - - 24 miles.

ECONOMIC GEOLOGY.

By J. A. WATT, M.A., B.Sc.

A.—GOLD.

The highly metamorphic character of the Pre-Cambrian rocks of the McDonnell Ranges, their greatly disturbed state, their extensive development, and lastly the presence of numerous intrusive masses varying much in composition, are all circumstances favourable to the development of mineral deposits in them. Gold is the only mineral that has been found in payable quantities in these ranges, and that only in a very limited area of about fifty square miles, situated seventy to eighty miles E.N.E. of Alice Springs, on the Arltunga or Paddy's Hole goldfield. Although, as just stated, gold in payable quantities has been found on the above-mentioned goldfield, yet alluvial gold in small quantities has been found also near Winnecke's Depot, Bald Hill, and in some of the gullies in the Georgina Range.

The greater portion of the alluvial gold has been obtained from a red clayey washdirt occurring in the narrow gullies which take their rise in a low range. The sinking is exceedingly shallow over the entire field, ranging from a foot or two up to eight or ten feet, the average being about four to five feet. The bottom is often very soft, being usually formed by gneiss, which is in a very weathered state, and therefore soft and friable. The concentration of the gold in the washdirt has not been satisfactorily accomplished, necessitating in many instances the washing of the greater part of the alluvium, as the overlying alluvial detritus is often as rich as the so-called washdirt. Much of the gold won from the gullies is very fine, a character shared by much of the reef gold also, and consequently difficult to save. The largest nugget found on the field was taken from Red Gully, and weighed two ounces three pennyweights. "Surfacing" has been attempted in a few places, notably on the west side of Kangaroo Creek, where the surface was removed to a depth of six to eight inches. Owing, however, to the scarcity of water, and the heavy expense of carting it, when obtainable, to the claims, this work had to be abandoned as unprofitable, in spite of a fair yield of gold.

The most important auriferous quartz reefs have a prevailing due north and south trend, and their gold contents show a remarkable uniformity. The

country-rock includes metamorphic gneisses and mica schists, intruded by eruptive dykes. Where not absolutely vertical the underlay is almost without exception to the west, and varies from 5° to 10°. The outcrops of these reefs, which are not, as a rule, traceable for any great distance, vary in width from four inches to two feet six inches, while at the bottom of trenches and shafts the width varies from three inches up to four feet six inches. Taking the average of ten reefs, the width at the surface was found to be twelve inches, while at an average depth of twenty-one feet it was fifteen inches. Gold is contained not only in the veinstone but occasionally and in a less degree in the selvage also, on one or both sides of the reef. In nearly all the reefs the gold is associated with gossary quartz, some of the best results being obtained from a spongy siliceous matrix, which crumbles easily when subjected to pressure. The oxide of iron has been derived from the oxidation of iron pyrites, and in many cases of copper pyrites also. Derived from the copper pyrites, or in some cases from sulphides of copper, there are present the green carbonate (malachite) and the blue carbonate (azurite) of copper.

The following is as complete a list as possible of the results of samples taken for treatment to the Huntington Mill erected at Claraville:

Name of Mine.	Quantity Treated.	Yield of Gold per Ton.	Remarks.
Monarch	5 Tons	1oz. 2dwts.	—
Wipe Out	10 ,, (?)	1 ,, 10 ,,	—
Matrix	1 ,,	7 ,,	—
Orient	9½ ,,	13 ,,	—
Round Hill	½ ,,	6oz.	Said not to be picked stone
,,	2½ ,,	10dwts.	Probably heavy loss during treatment
Extension of Bee Hive	5 ,,	17 ,,	—
Wheal Mundi	3½ ,,	1oz. 1 ,,	—
Wheal Fortune	32 ,,	13 ,,	—
,,	20 ,,	17 ,,	—
Name of mine unknown to me	20 ,,	18 ,,	—
,, ,,	14 ,,	1oz. 4 ,,	—
,, ,,	10 ,,	1 ,, 3 ,,	—
,, ,,	12 ,,	1 ,, 3 ,,	—

The total result of these crushings is that 145 tons yielded 140oz. 10dwts., or at the rate of over 19dwts. per ton.

B.—MICA.

On the north side of Hart Range intrusive dykes of a very coarse-grained granite occur, from a few of which a large quantity of mica has been taken and despatched to Europe *via* Adelaide. Only a few of the most promising of these dykes have had any attention given to them, and on these very little systematic work has been done. The reason for this is that, owing to the many drawbacks, among which may be mentioned their enormous distance from a railway and want of capital, it has been found necessary to pick out the best of the mica obtainable at or within twenty or thirty feet of the surface. As the descent was being made from the summit of Hart Range, near Mount Brassey, to the valley on the north side, bright glistening patches could be seen dotted about, indicating the position of these granite dykes. This glistening effect was produced by the reflection of the sun's rays from the surfaces of innumerable sheets of mica, derived from the breaking up of the large crystals of this mineral, that were liberated as the weathering of the granite progressed.

The Oolgarna Claim is situated on the western slope of a short northern spur of Hart Range, and about 300 feet above the valley. A large granite dyke occurs there, worked at the time of my visit by Messrs. Hall and Chambers, from which mica was being obtained at and near the surface. This dyke has intruded the gneiss almost vertically, with a N.W. and S.E. strike. Besides the purely surface-work an open cutting twenty-five yards long has been made on the trend of the mass, the height of its eastern face being from fifty to sixty feet.

In the cutting the distribution of the constituents of the granite could be readily perceived. The felspar, of which there are two varieties, is developed on an exceptionally large scale. Some detached pieces must have weighed from one to two cwt. Next in size is the quartz, large, clear, glassy masses of which were seen intimately associated with the felspar, with which it is often intercrystallised, even on a large scale.

The mica, the only mineral commercially important, was found to be largely developed near the walls of the dyke, and to a less extent towards the centre of the mass. That occurring on or near the surface, or near the walls, is usually more or less stained with oxide of iron, and perhaps manganese also; while that obtained from the parts of the rock out of reach of percolating water, *i.e.*, towards the centre of the mass, is clear and without stains, though somewhat dark, and generally rather smaller in size. Besides this marketable mica (*Muscovite*), there occur at rare intervals somewhat large masses of a very dark mica (*Biotite*), the

laminæ of which are much bent and opaque, even in thin plates. The largest piece of Muscovite mica obtained from this claim was, as I was informed, nearly six feet in length. The mica was cut into rectangular plates varying in size by half inches, from a few inches up to a foot or more in length, the cutter making the most of the mica, while no attempt was made to cut it into sizes to suit the market. When cut it is packed at the mine and conveyed by camel teams to Oodnadatta, a distance of more than six hundred miles.

During our visit only the mica from the surface, which is, as stated above, stained brownish-black or reddish-brown by peroxide of iron or manganese, was being cut and despatched, as there was said to be a good demand for that class of mica for electrical purposes, the unstained varieties being of course too costly to be applied to such a use.

On the opposite slope of this spur, and a few hundred feet below its summit, there is situated a mica claim, the ownership of which was in dispute. The granite at this claim strikes in an E.S.E. and W.N.W. direction, and has an underlay of about 45° to the S.S.W. A tunnel from eight to ten feet in height has been driven into the hill along the course of the dyke for a distance of thirty feet. The mineralogical composition of this granite is much the same as that of the Oolgarna granite, with the exception that in the former no biotite was observed.

The muscovite mica, though comparatively free from oxide of iron stains, was marked with light green spots, which would detract somewhat from its value. The best of the mica occurs near the south wall, and usually one or more crystal faces are developed. The largest sheet obtained from this dyke measured, when uncut, two feet long, two feet wide, and eighteen inches thick ; and, when cut, eighteen inches in all dimensions.

Six miles west of the Oolgarna claim, and two miles east of Mount Mabelle, another granite dyke is situated, which was being worked by Mr. Luce's party. The mica was obtained for the most part from shallow open cuttings. A shaft, however, has been sunk on the dyke to a depth of twenty-seven feet, at the bottom of which the dyke was found to have narrowed down from five feet, its width at the surface to three feet. No mica of any value was obtained from the shaft, which was put down with the intention of driving eastwards along the trend of the dyke, to test its mica contents below the point where it appears widest at the surface. In the case of this dyke, too, the largest mica plates were obtained in close proximity to the walls. The mineralogical composition is identical with that of the granite dykes described above. Further west good mica has been obtained

from Pope's and Mount Riddock claims, some of it being of a beautiful ruby tint. The greater portion, however, of this mica was much spotted. No information with reference to the financial aspect of this industry was obtainable, owing to the existence of great rivalry between those interested in the several claims. An examination of the optical properties of this mica shows that the optic axial plane lies across the symmetrical track or guide-line of the percussion-figure. This fact places it in Tschermak's first order. The angle c : $\mathfrak{a}$ (axis of greatest elasticity) is inappreciable, and the angle between the optic axes is large. Thin cleavage flakes of the dark mica (*biotite*) which are of a dark brownish-green colour, give a uniaxial figure, the angle c : $\mathfrak{a}$ being inappreciable.

The following explanation is suggested of the observed fact of the occurrence of the greater part of the large mica crystals near the walls of the dyke:—An examination of the hand specimens makes it perfectly clear that the mica was the first mineral to commence the process of crystallising out. As that portion of the granite near the walls, consequent upon the deprivation of some of its heat by contact with the neighbouring rocks, would be the first to cool sufficiently to allow crystallisation to proceed; it is there that we would have the nuclei of the future crystals formed. The result of this would be the formation of crystals of mica near the walls; while, judging by the large dimensions of the crystalline constitutents, the bulk of the igneous mass was, and for a considerable time remained, liquid. The mica crystals would, therefore, attract to themselves the necessary molecules, which would be enabled to answer to the attracting force as long as the mass was sufficiently fluid.

The mica crystals would not, however, become distributed through the mass, as they would naturally rapidly avail themselves of the molecules that were in close proximity to them, and thus become too large to be influenced by the currents that bring within their sphere of attraction the molecules needed for their growth. So an undue proportion of the mica substance would crystallise in close proximity to the walls, leaving the bulk of the rock with less than its due proportion of this mineral, felspar and quartz greatly predominating towards the centre of the mass.

C.—GARNETS.

The garnets that were asserted to be rubies, for a short time after their discovery, occur in large quantities in the bed of the Maude and Florence Creeks, which take their rise on the Southern slope of Hart Range, and more or less plentifully over the surface of the country drained by these creeks. The best stones

were obtained by washing the "dirt" in the bed of the above-mentioned creeks until the material is reduced sufficiently to permit the rounded water-worn garnets to be picked out by hand. Although the garnets are exceedingly plentiful, yet good unfractured and clear stones are comparatively rare. The fine surface sand of the beds of the creeks was often observed to have a beautiful claret-red tinge, due to the intermixture of innumerable small fragments of garnet with the sand. The source of the garnets was found to be a garnetiferous gneiss very rich in this mineral, a typical specimen of which was gathered from an outcrop on the banks of the Maude Creek.

An analysis of some specimens of these garnets has been made by Prof. E. H. Rennie, with the following result* :—

Silica (SiO_2) - - - -	38·48	per cent.
Alumina (Al_2O_3) - - - -	27·06	„
Ferrous oxide (FeO) - - -	26·28	„
Lime (CaO) - - - -	1·99	„
Magnesia (MgO) - - - -	4·20	„
Oxide of manganese (MnO) - -	·35	„
	98·39	

"All the iron has been reckoned as protoxide, while some at least of it exists as peroxide."

* On some so-called South Australian Rubies, by Prof. E. H. Rennie, D.Sc., Trans. and Proc. and Report of the Roy. Soc. South Australia, vol. xi. (for 1887-8).

PETROLOGY.

By W. F. SMEETH M.A., A.R.S.M., and J. ALEX. WATT, M.A., B.Sc.

(PLATES 1–4).

Introduction.

The lithological specimens gathered during the Horn Expedition to the McDonnell Ranges include examples of sedimentary, eruptive, and metamorphic rocks. The purpose of this paper is to give merely a short description of the microscopical structure of some of the eruptive and of a few of the most typical of the metamorphic varieties. The region from which almost all the rocks here described were gathered includes portions of the McDonnell and Hart ranges. A general description of some of the granites has already been given in the chapter dealing with the "Geology" of the region; there will be added here a few notes only on the felspars.

Although time has not permitted much detailed work on the specimens here described, there are one or two points to which we should like to draw attention. One is the beautifully developed, though very minute, micro-pegmatitic structure in No. 215. The inter-crystallisation of the felspar and quartz is on so fine a scale that very considerable magnification is needed to recognise it. It was, in fact, a puzzle for some time, until a general similarity to No. 220, where the structure is more coarsely developed, gave us a clue to its real nature. Under moderate magnifying powers the appearance is that of a number of compacted grains which do not extinguish under crossed nicols in any position, but are darker in some positions than in others. Owing to this, and also to the fact that some of the grains are built up of sections arranged around some central object, generally a piece of felspar, the different grains are distinguished from one another.

Another point worthy of notice is the evidence that much of the hornblende in the diorites Nos. 25, 32, 19, has been derived from augite. These secondary hornblendes are compact and strongly coloured, the tints ranging from greenish-blue to brown, while the augite grains are comparatively light in colour. It is questionable whether this can be considered a "paramorphic" change, or whether

the term "uralite" can be justly used for such material. Typical uralite, of which Nos. 73, 105, 123, afford examples, is not strongly coloured, and usually retains the form of the original augite grains; the planes of symmetry of the hornblendes and augites being parallel. In the present cases, on the contrary, the hornblendes do not appear to have any definite morphological relation to the augites, and they are strongly coloured, and probably contain much more iron than the latter. These points would seem to indicate a re-crystallisation of the augite material, together with either a bleaching of the residual augite, or extraneous addition of iron, or both, rather than the gradual paramorphic change of material from one crystalline condition to another. Whether the resulting hornblende, in one case or the other, is fibrous or not is probably unessential.

In calling attention to this point we desire merely to point out that we have here rocks containing a large proportion of compact, strongly-coloured hornblende, and that there is strong evidence that much of it has been formed of material previously crystallised in the form of augite.

Our best thanks are due to Professor T. W. E. David for his kindness in allowing the sections to be cut in the Geological Laboratory of the Sydney University, and to Professor Judd, who so kindly placed at our disposal microscopes and a room at South Kensington for the use of the artist engaged in lithographing the plates.

SEDIMENTARY ROCKS.

Arkose. No. 213. Plate III., Fig. 3. Sp. gr. 2·61.

Ayers Rock, a physical feature of great interest, a description of which is given in the chapter dealing with the "Physical Geography," is entirely made up of this rock. A short note is given on this rock because it has been so often called a granite, and, though bearing a somewhat superficial resemblance to a granite in its macroscopical features, on examination is found to be a rock of sedimentary origin. It is composed of more or less rounded grains of quartz and felspar, with a large amount of cementing material, consisting of brown and red oxides of iron and a little magnetite, probably derived from biotite which has entirely disappeared. The felspar grains consist of microcline, some of them remaining fairly fresh, whilst others are considerably kaolinised. Some of the microcline grains show the carlsbad twining in addition to the characteristic micro-structure.

FELSPARS.

Plagioclase. No. 147. Plate III., Fig. 2.

This section exhibits what appears to be an inter-growth of felspar and mica. There are several pieces of mica with well-marked basal cleavage, showing that the section is cut at right angles to the basal plane. All the pieces of mica are in optical continuity, as shown by their extinguishing simultaneously. The felspar is a plagioclase with very low extinction angle. The section was obtained by grinding down a cleavage flake parallel to the brachypinacoid (010). On examination "under crossed nicols" the felspar and mica are seen to extinguish practically simultaneously. It seems probable that the several pieces of mica formed part of a single plate, which lay parallel to the basal plane of the felspar.

Microcline. No. 18*a*. Plate III., Fig. 4.

This is a section of microcline obtained by grinding down a basal cleavage flake, and shows in an excellent manner the "cross-hatched" structure. In the microcline are to been seen strings of a plagioclase, with low extinction angle, arranged in a roughly parallel manner. The several plagioclase strings are in perfect optical continuity with each other, and exhibit the albite type of twinning. They probably occupy the sites of cracks, which have been filled by a secondary growth of felspar differing in composition and micro-structure from the original felspar.

Plagioclase. No. 15*a*. Plate III., Figs. 5 and 6.

This is a plagioclase that is very common in these granites of the Hart Range. The albite type of twinning is developed in a wonderfully perfect manner, and the angle of extinction measured from these twinning planes does not exceed 2° or 3°. The sections were obtained by grinding down cleavage flakes parallel to the basal plane (001).

In Fig. 6 is given a drawing of another basal section, in which masses of felspar, exhibiting the characteristic microcline structure, are seen to be enclosed in the plagioclase. Whether these represent original inter-growths, or cavities subsequently filled with felspar of a different composition to the original, or a product derived from the alteration of plagioclase *in situ*, it is difficult to decide. The last seems the most probable explanation.

ERUPTIVE ROCKS.

Micro-pegmatite. No. 220. Plate I., Fig. 1, and Plate IV., Fig. 2*a*.

This is a holo-crystalline granitic rock composed of felspar, quartz, dark ferruginous mineral patches, and what may be termed a groundmass of irregular grains of micro-pegmatitically inter-crystallised quartz and felspar. There are only a few scattered grains of quartz in addition to that inter-crystallised with the felspar. There are, however, many crystals of felspar, some of them having somewhat idiomorphic contours, while all are rendered cloudy from the presence of decomposition products. In addition there are several irregular dark patches consisting principally of red oxide of iron, but also to a less extent of magnetite. These patches occupy the sites of, and have resulted from the decomposition of, a ferruginous mineral which has left insufficient evidence to enable its species to be determined. The greater part of the rock is composed of inter-locking micro-pegmatitic grains, the boundaries of which are not evident, until the rock is examined "under crossed nicols." The drawing of the figure (Fig. 1) has been made in ordinary light, and a few faint lines have been put in to indicate the boundaries of the micro-pegmatitic grains as seen in polarised light. Several of the grains exhibit an irregularly divergent arrangement of quartz and felspar rays branching out from a piece of felspar occupying the centre of the grain. The central piece of felspar is occasionally observed to be in optical continuity with the felspar of the surrounding micro-pegmatitic mass. This divergent arrangement corresponds somewhat to the granophyric structure of Rosenbusch. It has been noticed that in one or two cases the central pieces of felspar exhibit simple twinning, and that this arrangement is continuous throughout the external micro-pegmatitic portion of the grain.

In Plate I., Fig. 1, the felspar of the micro-pegmatitic grains is shown by light shading corresponding to its cloudy appearance under the microscope.

In Plate IV., Fig. 2*a*, a small grain exhibiting the micro-pegmatitic structure has been highly magnified and drawn "under crossed nicols," the felspar being extinguished and the triangular masses representing the quartz. This specimen formed part of a pebble from the Mount Olga conglomerate.

Micro-pegmatite. No. 215. Plate I., Fig. 2, and Plate IV., Fig. 2*b*. Sp. gr. 2·71.

This rock is apparently a variety of No. 220, but in this case the micro-pegmatite is developed on a very fine scale, and is to be clearly made out only under

high magnification. As in the case of No. 220 the rock has a granular structure which is well-marked "under crossed nicols." A few lines have been put in the drawing (Plate I., Fig. 2), to indicate the outlines of the grains. The quartz and felspar components of the micro-pegmatitic grains are frequently arranged in parallel lines presenting the appearance of innumerable fine striations, which is well seen in Plate IV., Fig. 2*b*, where one of the constituents is extinguished. At other times they completely inter-ramify, giving a homogeneous appearance, the complexity of which is recognisable only under considerable magnification. The mass of the rock is made up of compacted grains of the above nature.

In addition to this there are a few small granules of quartz, and a fair number of kaolinised idiomorphic crystals of felspar. Some of the latter are surrounded by micro-pegmatite arranged in irregular radial sectors.

A pale pyroxene is distributed in small grains through the rock as well as a fair amount of magnetite, and a little red oxide of iron. Much of the magnetite as well as a pleochroic bluish-green mineral appears to have resulted from the decomposition of part of the pyroxene.

An important feature of the rock is the presence in most of the micro-pegmatitic grains of numerous needle-like inclusions, which are aggregated in diverging groups. These inclusions are very often absent from the centre of the grains, apparently not having made their appearance till part of the grain had crystallised out. Under a high power these needle-like inclusions are seen to be composed of longulites of a pale green colour, which are irregularly aggregated along straight lines, and appear to have been formed contemporaneously with the micro-pegmatite. This specimen was also obtained from a pebble occurring in the Mount Olga conglomerate.

Granulitic pyroxene diorite. No. 25. Plate I., Fig. 3, and Plate IV., Fig 1*a-b*, and Fig. 5*a*. Sp. gr. 3·09.

This is a fine grained rock with a sub-conchoidal fracture, not unlike a basalt in appearance, but rather lighter in colour. Small dark grains are distinguishable by the naked eye, and colourless particles of about the same size; the former prove under the microscope to be augite and hornblende crystals, and the latter porphyritic plagioclase crystals. It is composed of an aggregate of granular crystals of felspar, hypersthene, augite, and magnetite, which with the exception of a few of the felspar and augite crystals are of an uniform size. There are, however, some porphyritic crystals of plagioclase in lathe-shaped sections, and of a pale green augite.

The porphyritic felspars have high extinction angles, between labradorite and anorthite, and contain numerous inclusions of two kinds:—(1) A fine microscopic dust, Plate I., Fig. 3, and Plate IV., Fig. 1*b*, occupying the centre of each crystal, the outer shell being usually free from it. This dust appears to be composed of globulites, some of which consist of magnetite, while others are transparent; and, (2) very fine elongated granules of augite, Plate IV., Fig 1*a*, arranged in the centre of the crystal in a layer parallel to 010. Occasionally some granules of augite similar to those in the groundmass of the rock are included. The external boundaries of the crystals are more or less infringed by granular augite and hypersthene.

The porphyritic augite, Plate I., Fig. 3, is pale green in colour, similar to the granular crystals, but showing often a fibrous structure parallel to the vertical axis, somewhat suggestive of diallage. The extinction angle is, however, as large as 42°. The crystals, as a rule, show platy metallic inclusions, Plate IV., Fig. 5*a*, lying parallel to 100, similar to those occuring in some diallage, as well as small granules of magnetite. These crystals usually exhibit alteration into green hornblende, Plate IV., Fig. 5*a*, the uralite (?) so formed being present in considerable amount. These secondary hornblendes are compact, and do not exhibit the usual fibrous structure of uralite.

The granular hypersthene exhibits a somewhat slight pleochroism, brownish-pink and green being the predominating colours.

The granular felspar appears to have been the last mineral to crystallise out, and occurs in small clear irregular grains, lamellar twinning being occasionally visible. All the minerals are singularly fresh and clear. The specimen was obtained from a dyke intruding gneiss on the northern slope of the Hart Range, and in close proximity to the large coarse-grained granite dyke, on which the Oolgarna Mica Claim is situated.

Diorite. No. 32. Plate I., Fig. 4.

The greater part of this rock is composed of typical green hornblende, which is very clear and fresh, and thoroughly allotriomorphic. A certain amount of comminuted material of a pale greyish-green colour is present. This has a high index of refraction and strong double refraction, and probably represents the *débris* of some augite grains. These patches of powdered augite are almost invariably surrounded by grains of hornblende, which seem to pass indefinitely into the powdered materiai. This is readily observed by the gradual loss of the

strong pleochrosim of the hornblende. The rest of the rock is composed of clear granular plagioclase, with apparently high extinction angles. The hornblende fills in accurately the spaces between the granules of felspar, while a number of small felspar grains are completely included in some of the hornblende crystals. In the mass the rock appears to have been subjected to a certain amount of crushing. This rock occurs as an intrusive dyke in the McDonnell Ranges, near Fish Water Hole, on Ellery Creek.

Diorite. No. 19. Plate I., Fig. 5, and Plate IV., Figs. 5*b*, 6*a*. Sp. gr. 2·99.

The essential constitutents of this rock are hornblende and plagioclase. The felspar is clear and fresh, but shows signs of crushing, the twin lamellæ being in places discontinuous and bent (Plate IV., Fig. 6*a*). Two sets of twinning are often to be seen, and a series of solution cavities appear frequently to be developed, the longer axes of which lie parallel to the trace of the plane 010. Occasionally these cavities have a dendritic form, and are filled with a yellowish ferruginous material. Compact greenish-brown hornblende is present in considerable quantity in large, clear and fresh grains with very irregular outlines, being formed subsequently to the majority of the felspars. Closely associated with these are numerous grains of a very pale green augite (Plate I., Fig. 5), shown by stippling, most of which show in places transition into hornblende (Plate IV., Fig. 5*b*), which is identical in character with the rest of the hornblende.

This suggests the possibility of much of the hornblende having been formed at the expense of augite. This view is supported by the fact that the augite grains have suffered considerably in the crush, while the grains of hornblende show little cracking or dislocation. At present the hornblende is in considerable excess of the augite, and in fact appears to form about one-half of the whole mass of the rock. Inclusions of felspar are common in both the grains of augite and hornblende. In a portion of one slide a great number of granular zircons lie included in the hornblendes ; a few of them are present also in the felspars. This rock occurs at Mount Brassey, in the Hart Range.

Gabbro. Nos. 109 and 90. Plate II., Fig. 3.

In thin sections this rock is seen to be a granular aggregate of crystals of diallage, plagioclase and magnetite, with a small quantity of greenish decomposition products. Although the pyroxene exhibits more or less well-developed

crystalline boundaries, it must be placed amongst diallages, in virtue of the development, especially in the neighbourhood of cracks, Plate II., Fig. 3, of a fibrous structure parallel to the vertical axis, and the comparatively low extinction angles, which seldom exceed 31°. On the orthodiagonal section the optical sign is positive. The felspars have fairly high extinction angles averaging about 26° or 27°, which indicates a composition near that of bytownite. Magnetite is rather plentiful, and in the form of large irregular grains. Fine acicular crystals of apatite occur in the plagioclase, and traverse small grains of secondary quartz. There are present, as additional secondary minerals, small pieces of a greenish-yellow mica, with strong absorption, surrounded by a small quantity of a greenish decomposition product and a little pyrites. Some of the felspars have been replaced by an aggregate of minute particles of calcite. This rock occurs, between Slip panel Gap and Ellery Creek, intruding gneiss.

Dolerite. No. 99. Plate IV., Fig. 6*b*. Sp. gr. 3·03.

This rock is very similar to Nos. 195 and 179. It is a coarse-grained rock consisting of plagioclase, augite, olivine, and magnetite.

The felspar crystals often present the two (abite and pericline) types of twinning. There is strong evidence of zoning, which is made apparent by the "shadowy" extinction. The angles of extinction vary from the exterior to the centre of the crystals, the external portions often having an almost straight extinction, while the central portions extinguish at an angle of about 31°. From this we may conclude that the outer portions of the felspar crystals belong to the soda end of the soda-lime series, while the central portions belong to the lime end.

The transition from felspar of one composition represented by the high extinction angles to that of a very different composition represented by the low extinction angles is not perfectly progressive. The process of the separating out of felspar of a gradually changing composition seems to have received a check at a given stage, when for a certain space of time felspar of a fixed composition seems to have crystallised out. This was the most stable felspar under the circumstances, that is, that most able to maintain a fixed composition in spite of the changes taking place in the magma. The most stable felspar in this case appears to have been one with an extinction angle between 18° and 28°.

The augite in thin sections is of a pale brownish-yellow colour.

Olivine, Plate IV., Fig. 6*b*, occurs in irregularly-shaped grains which are much cracked, the cracks being to a great extent filled with fine grains of

magnetite. A little chlorite, a few flakes of biotite, and a little iron pyrites are present as accessory minerals. Granular augite occurs in ophitic patches, enclosing sometimes two or three felspar crystals. The order of crystallisation appears to have been as follows :—magnetite, felspar, olivine, and augite. The rock occurs intruding gneiss near the head of Ellery Creek.

Olivine Dolerite. Nos. 195 and 179. Plate II., Fig. 1, and Plate IV., Fig. 4. Sp. gr. 3·07.

The felspar of this rock resembles in all respects that described in specimen No. 99. The augite has its usual characters, the only feature that need be noticed is its occurrence in large ophitic masses, well shown in Plate IV., Fig. 4. The olivine, which is present in large quantity, is almost entirely undecomposed ; there are numerous cracks, however, in the crystals, which are filled with fine magnetite grains. A few grains of hypersthene are present with comparatively feeble pleochroism, *c* being green, and *b* pink. This rock occurs between Slip-panel Gap and Ellery Creek, as a dyke-intruding gneiss.

Fine-grained Dolerite. Nos. 79 and 121. Plate II., Fig. 2. Sp. gr., No. 79, 2·95 ; No. 121, 2·97.

The plagioclase crystals are lathe-shaped and have high extinction angles. The augite is the ordinary brown basaltic variety occurring in fairly uniform grains, some of which are quite fresh, while others are altered into pseudomorphs of chlorite, fibrous hornblende, and probably also serpentine. Ophitic structure is exhibited in parts. This rock intrudes gneiss between Slip-panel Gap and Ellery Creek.

Dolerite. No. 64. Plate IV., Fig. 3.

This rock, which is much decomposed, consists essentially of plagioclase, augite and ilmenite. The plagioclase is much decomposed with the production probably of a moderate amount of saussurite. The augite has crystallised out early, there being no inclusions of felspar in it. Simple, and perhaps also multiple, twinning is exhibited by some of the augite crystals. Alteration has gone on in places, granular epidote, chlorite, and a fibrous hornblende being developed. The place of magnetite is taken by ilmenite, Plate IV., Fig. 3, which occurs in the form of irregular flat grains, exhibiting the characteristic hatched appearance in incident light. A little secondary quartz and a few

pieces of a dark brown mica are present as alteration products. This rock occurs intruding gneiss between Slip-panel Gap and Ellery Creek.

Epidote Rock. No. 65. Plate II., Fig. 4. Sp. gr. 3·20.

This rock consists of epidote, hornblende, and a little felspar mostly secondary. The epidote, which forms more then one-half of the rock, is irregularly granular, with the usual pleochroism, and is probably due to the alteration of the felspar, and in some degree of the hornblende. The latter occurs in crystals, which appear to have suffered considerably during the formation of the epidote. The pleochroism of hornblende appears bluish-green parallel to c, yellowish-green parallel to b, and pale yellow parallel to a. The pleochroism is uncommon, and a reedy fibrous structure is apparent in most of the sections, Plate II., Fig. 4. In parts it shows alteration into flakes of a brownish mica. This rock occurs on the side of dolerite intrusion between Slip-panel Gap and Ellery Creek.

Amphibolite. No. 16.

This rock is somewhat foliated with a little secondary quartz in veins. It is almost entirely composed of crystals of hornblende having a remarkable pleochroism. The extinction is 20° on the clinopinacoid. The pleochroism is $\mathfrak{c}$ strong greenish-blue, $\mathfrak{b}$ olive-green, and $\mathfrak{a}$ pale yellow. Some sections exhibit a very finely striated appearance. A certain amount of mica is also present, some of which is a dark biotite, the greater portion, however, is a bluish-green biotite, which is practically uniaxial, and has a pleochroism varying from dark green to yellow. This rock comes from Claraville in the East McDonnell Ranges.

Uralitic amphibolite. Nos. 73, 105, 123. Plate I., Fig. 6. Sp. gr. 3·06.

In the mass it is composed of greyish-green fibrous hornblende, with a certain amount of a paler green augite scattered through it. In section by far the greater portion of the rock is seen to be composed of hornblende, the pleochrosim of which is pale bluish-green, yellowish-green to nearly colourless. The crystals are irregularly interwoven without definite boundaries, and have a coarsely fibrous to patchy appearance in polarised light. The most striking feature is the frequent development of the prismatic cleavage in the hornblende. Amongst the hornblende irregular patches of colourless augite grains remain, and there is little doubt that these are the remains of pyroxenic minerals, which have yielded the hornblende by paramorphic change. The hornblende is in fact fairly typical uralite. This rock comes from Black Knob, near the head of Ellery Creek, in the McDonnell Ranges.

METAMORPHIC ROCKS.

Gneiss. No. 76. Plate III., Fig. 1.

This rock is somewhat foliated, which is not apparent in the drawing, as the section was taken parallel to the foliation planes. Biotite is present in flakes lying parallel to the foliation. The mass of the rock, however, is made up of irregular interlocking grains of quartz, with some irregular grains of clear felspar, together with a considerable number of idiomorphic and much decomposed felspars. A considerable quantity of epidote is distributed through the mass in short prismatic forms. This rock was obtained near Ellery Creek in the McDonnell Ranges.

Fine-grained Gneiss. No. 192. Plate II., Fig. 6.

Foliation is well marked in this rock by means of numerous parallel flakes of biotite. The mass of the rock is made up of small grains of quartz and clear triclinic felspar, with a certain amount of highly decomposed felspar. A colourless micaceous mineral is present in small quantities, which is probably sericite. A few large porphyritic grains of magnetite are scattered through the mass. This rock occurs on the south side of Mount Conway in the McDonnell Ranges.

Gneiss. No. 48. Sp. gr. 2·76.

This rock contains a considerable quantity of a yellowish epidote. The general texture is granulitic, with large porphyritic crystals of pink microcline. The mass of the rock is a granular aggregate of quartz and microcline. This specimen came from Haast's Bluff.

Biotite Gneiss. No. 107.

The constituents of this rock are biotite, triclinic felspar and some quartz, the whole showing strongly-marked foliation, the felspar grains being elongated parallel with the foliation. A small quantity of a pale rhombic pyroxene is present, as well as numerous small prisons of apatite. This rock occurs between Slip-panel Gap and Ellery Creek in the McDonnell Ranges.

Gneiss. No. 206.

Composed of a fine aggregate of quartz and felspar, a considerable amount of the felspar being converted in places into epidote. Through the mass

irregular patches of secondary quartz granules are distributed, which seem to have a somewhat parallel arrangement. Numerous small flakes of biotite are present, as well as some small apatite prisms. The brown biotite is in part connected into a green variety. This specimen came from the McDonnell Ranges between Slippanel Gap and Ellery Creek.

Augen-gneiss. No. 4.

This rock is of a basic character and allied to the diorites in composition, quartz being practically absent. The "eyes" consist of grains of triclinic felspar with a little green hornblende, while the foliated groundmass is composed of crushed fragments of felspar, dark brown biotite, and a little hornblende. Besides the above there are numerous pinkish-brown garnets and small grains of apatite and zircon. This rock was found on the banks of Maude Creek, in the Hart Range.

Gneiss. No. 23.

The bands of this gneiss are composed of granules of clear felspar and a little quartz alternating with layers of decomposed and fractured felspar grains. A pale granular epidote is abundant, and there are a number of thin irregular flakes of a white mica (*sericite ?*), which in places are aggregated into distinct bands. This rock formed the walls to the quartz reef on the Wheel Fortune Claim, in the Arltunga goldfields.

Augen-gneiss. No. 249. Plate II., Fig. 5.

The mass of the rock is made up of closely compacted "eyes," of fairly uniform dimensions, and consisting of grains of felspar mostly triclinic with a few grains of quartz. Surrounding these "eyes" is a very perfect flow-structure formed by strings of biotite altering into oxides of iron, and separated by layers of comminuted quartz dust probably mixed with secondary quartz.

EXPLANATION OF PLATES.

Plate I.

Fig. 1.—*Micro-pegmatite.* No. 220 × $\frac{75}{3}$.* Section drawn in ordinary light shows a few clear quartz grains, several "cloudy" pieces of felspar, and two large black patches of hæmatite and magnetite. The rest of the rock exhibits the irregular network of quartz and felspar of the micro-pegmatite grains, the latter constituent being shaded.

" 2.—*Micro-pegmatite.* No. 215 × $\frac{75}{3}$. Drawn in ordinary light. Micro-pegmatitic structure very fine, scarcely shown at all in this figure. Shaded portions are more or less decomposed, felspar crystals usually surrounded by the radiating inclusions. Faint lines have been drawn to indicate the boundaries of the grains of micro-pegmatite, although these are only to be made out under "crossed nicols."

" 3.—*Granulitic Pyroxene Diorite.* No. 25 × $\frac{75}{3}$. Felspars are colourless, with inclusions. Augite, both porphyritic crystals and small grains shown by light shading. Small grains of hypersthene shown by a little deeper shading. Hornblende by deeper shading. Numerous grains of magnetite shown black.

" 4.—*Diorite.* No. 32 × $\frac{35}{3}$. Drawn in ordinary light. Felspar clear. Hornblende shaded. Mass of comminuted augite shown at the bottom of the section.

" 5.—*Diorite.* No. 19 × $\frac{35}{3}$. Drawn in ordinary light. Felspar clear. Augite grains indicated by stippling. Hornblende shaded to indicate pleochroism.

" 6.—*Uralitic amphibolite.* No. 123 × $\frac{75}{3}$. Drawn in ordinary light.

Plate II.

Fig. 1.—*Olivine Dolerite.* No. 195 × $\frac{75}{3}$. Drawn in ordinary light. Augite exhibits ophitic structure. Olivine much cracked with magnetite in filling cracks.

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* The numerator of this expression indicates the magnifying power of the eye-piece and objective used in making the drawing; but as the image produced is reduced in the drawing one-third of its real size, the absolute degree of magnification of the minerals of the slide, as represented by the drawing, is denoted by the quotient.

Fig. 2.—*Fine-grained Dolerite.* No. 121 $\times \frac{7.5}{3}$. Drawn in ordinary light. Augite, plagioclase, and magnetite readily distinguishable. The more indefinite parts consist of alteration products—chlorite, fibrous hornblende, and serpentine.

" 3.—*Gabbro.* No. 109 $\times \frac{3.5}{3}$. Drawn in ordinary light. Clear pieces with needle-like inclusions are grains of secondary quartz with apatite. Felspar is partly decomposed, and diallage shows fibrous structure.

" 4.—*Epidote Rock.* No. 65 $\times \frac{7.5}{3}$. Drawn in ordinary light. Shows granular epidote and dark shaded masses of hornblende.

" 5.—*Augen-gneiss.* No. 249 $\times \frac{2.5}{3}$. Drawn in ordinary light, and shows "eyes" of felspar and quartz, and strings of biotite.

Fig. 6.—*Fine-grained Gneiss.* No. 192 $\times \frac{3.5}{3}$. Drawn in ordinary light. Section at right angles to planes of foliation. Large black mass is a grain of magnetite. Parallel flakes of biotite shaded dark. Colourless grains with well-marked outlines are grains of mica (sericite ?).

Plate III.

Fig. 1.—*Gneiss.* No. 76 $\times \frac{7.5}{3}$. Drawn in ordinary light. Section parallel to foliation planes. Numerous grains of epidote.

" 2.—*Plagioclase.* No. 147 $\times \frac{3.5}{3}$. Drawn in ordinary light. Basal cleavage of mica well-shown. Rest of slide consists of felspar. Extinction of mica and felspar is parallel to cleavage lines of the former.

" 3.—*Arkose.* No. 213 $\times \frac{3.5}{3}$. Drawn in ordinary light. Clear grains are more or less rounded particles of quartz. Shaded portions represent microcline grains. Irregular black patches consist of magnetite and hæmatite.

" 4.—*Microcline.* No. 18*a* $\times \frac{3.5}{3}$. Drawn "under crossed nicols." One-half of microcline is extinguished. Strings of plagioclase show albite twinning.

" 5.—*Plagioclase.* No. 15*a* $\times \frac{7.5}{3}$. Drawn "under crossed nicols." One-half of the plagioclase is extinguished.

" 6.—*Plagioclase.* No. 15*a* $\times \frac{7.5}{3}$. Drawn "under crossed nicols." Section of plagioclase with associated mass of microcline.

PLATE IV.

Fig. 1*a*.—*A Lathe-shaped Felspar.* No. 25 $\times \frac{250}{3}$. Drawn in ordinary light, but with some of the twinning planes shown. Linear inclusions of magnetite and augite grains, also fine microscopic dust.

,, 1*b*.—*A Felspar Grain.* No. 25 $\times \frac{250}{3}$. Drawn in polarised light to show arrangement of minute inclusions. Black lines represent extinguished twin lamellæ.

,, 2*a*.—Specimen No. 220 $\times \frac{250}{3}$. Drawn "under crossed nicols." A small grain to show micro-pegmatitic structure; felspar is extinguished.

,, 2*b*.—Specimen No. 215 $\times \frac{250}{3}$. Drawn "under crossed nicols." A highly magnified grain of micro-pegmatite showing parallel arrangement of quartz and felspar. One of the constituents is extinguished. A few inclusions are shown.

,, 3.—Specimen No. 64 $\times \frac{75}{3}$. Drawn in reflected light. Shows characteristic structure of ilmenite. Three sets of dark lines crossing at 60°. The black patches represent iron pyrites.

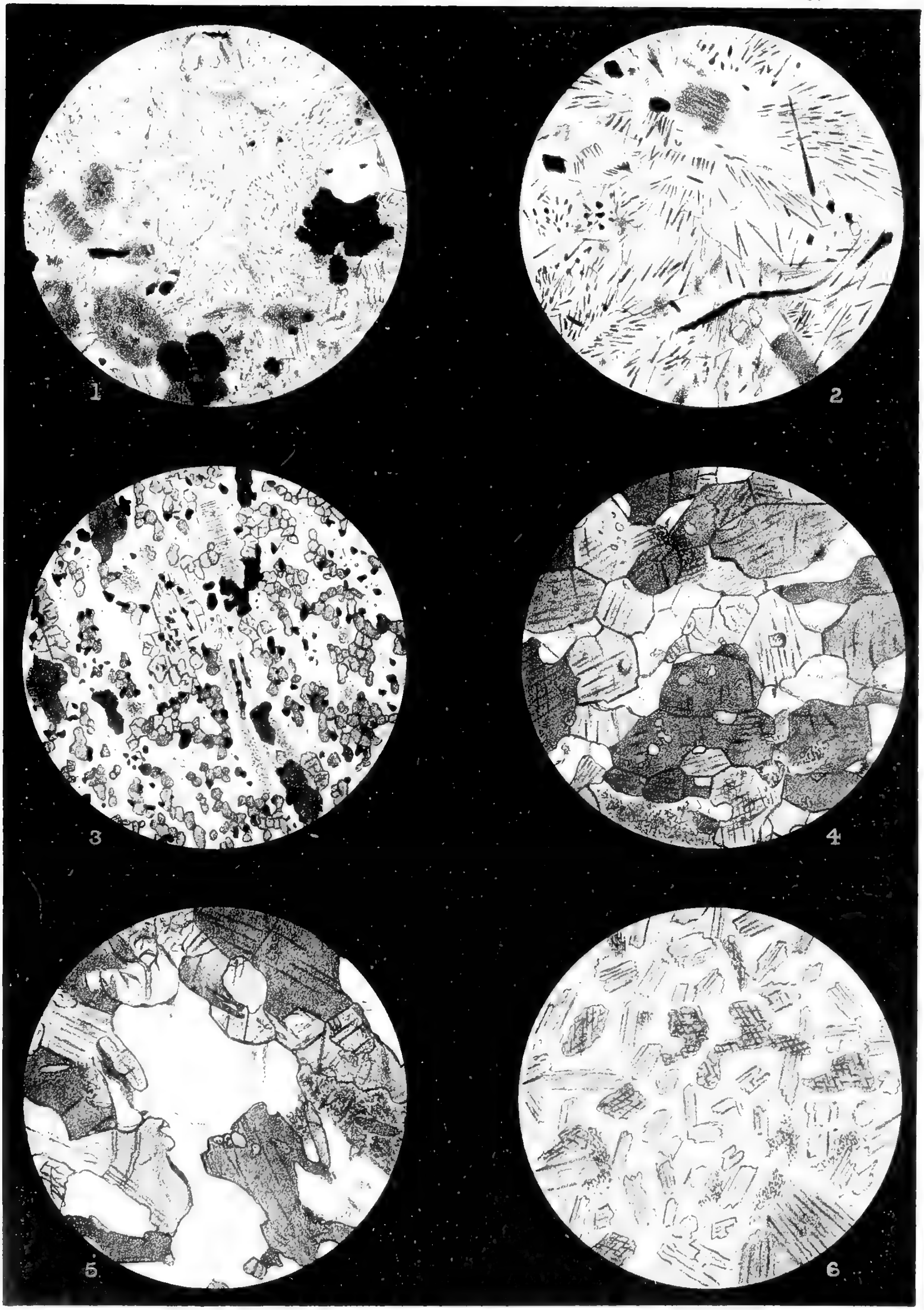
,, 4.—Specimen No. 195 $\times \frac{35}{3}$. Drawn in ordinary light to show ophitic structure.

,, 5*a*.—Specimen No. 25 $\times \frac{75}{3}$. Drawn in ordinary light. A porphyritic crystal of augite with metallic inclusions surrounded by grains of hornblende, which pass almost imperceptibly into the augite.

,, 5*b*.—Specimen No. 19 $\times \frac{75}{3}$. Drawn in ordinary light to show passage of augite into hornblende.

,, 6*a*.—Specimen No. 19 $\times \frac{75}{3}$. Drawn "under crossed nicols" to show bending of twin lamellæ of plagioclase.

,, 6*b*.—Specimen No. 99 $\times \frac{75}{3}$. Drawn in ordinary light to show irregular cracking of olivine crystal and infilling of magnetite.



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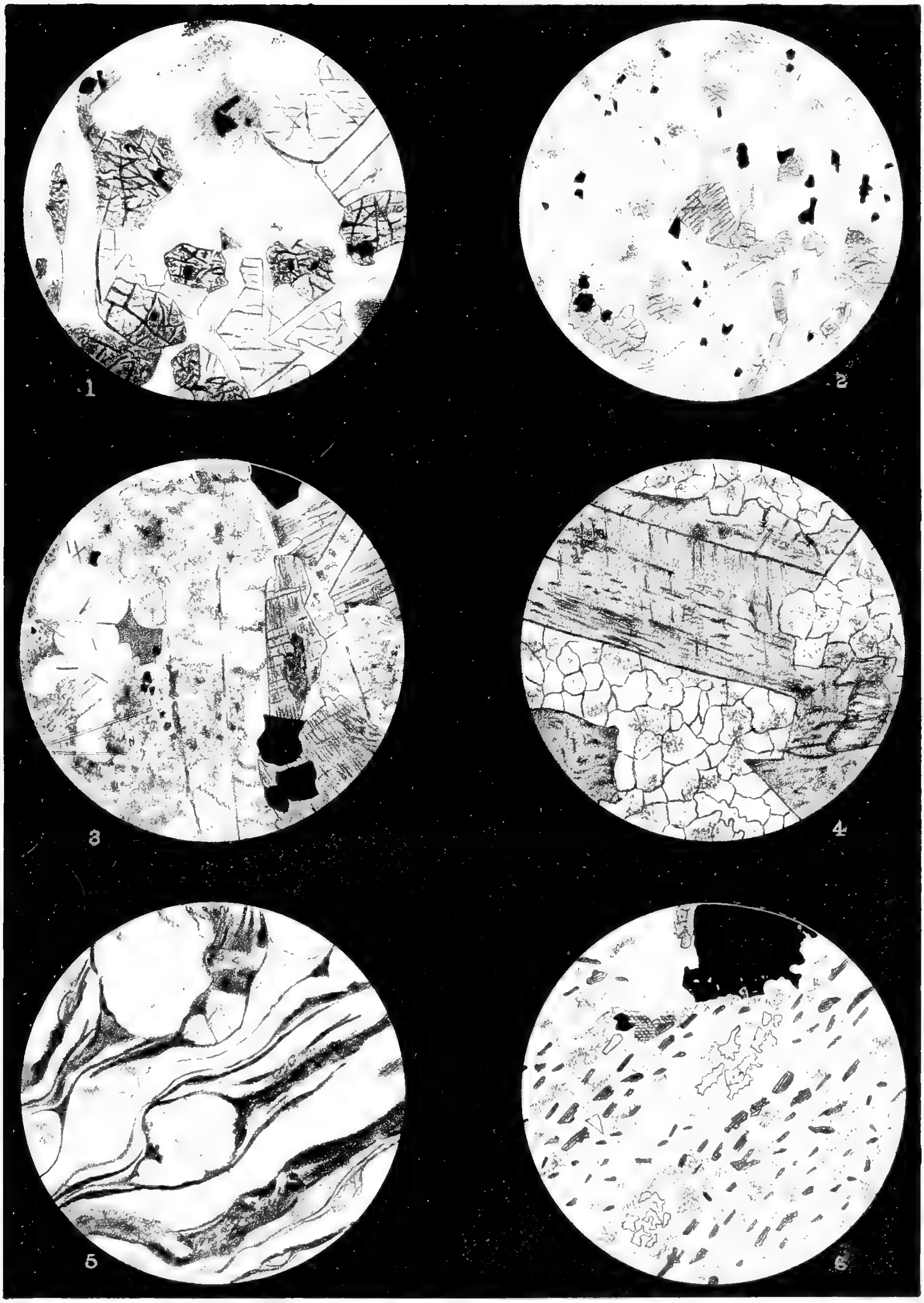
Some Varieties of Central Australian Rocks



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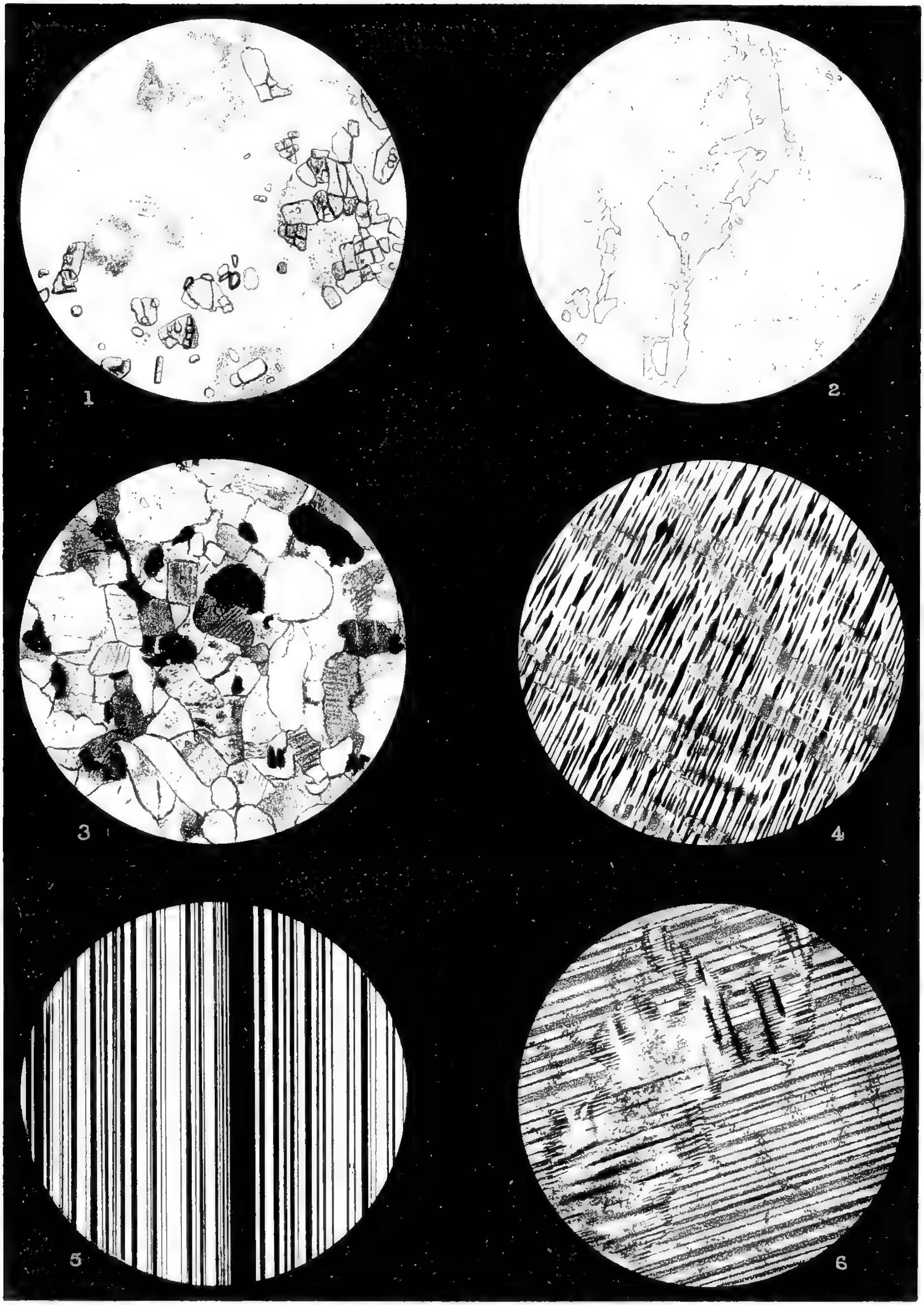
Some Varieties of Central Australian Rocks



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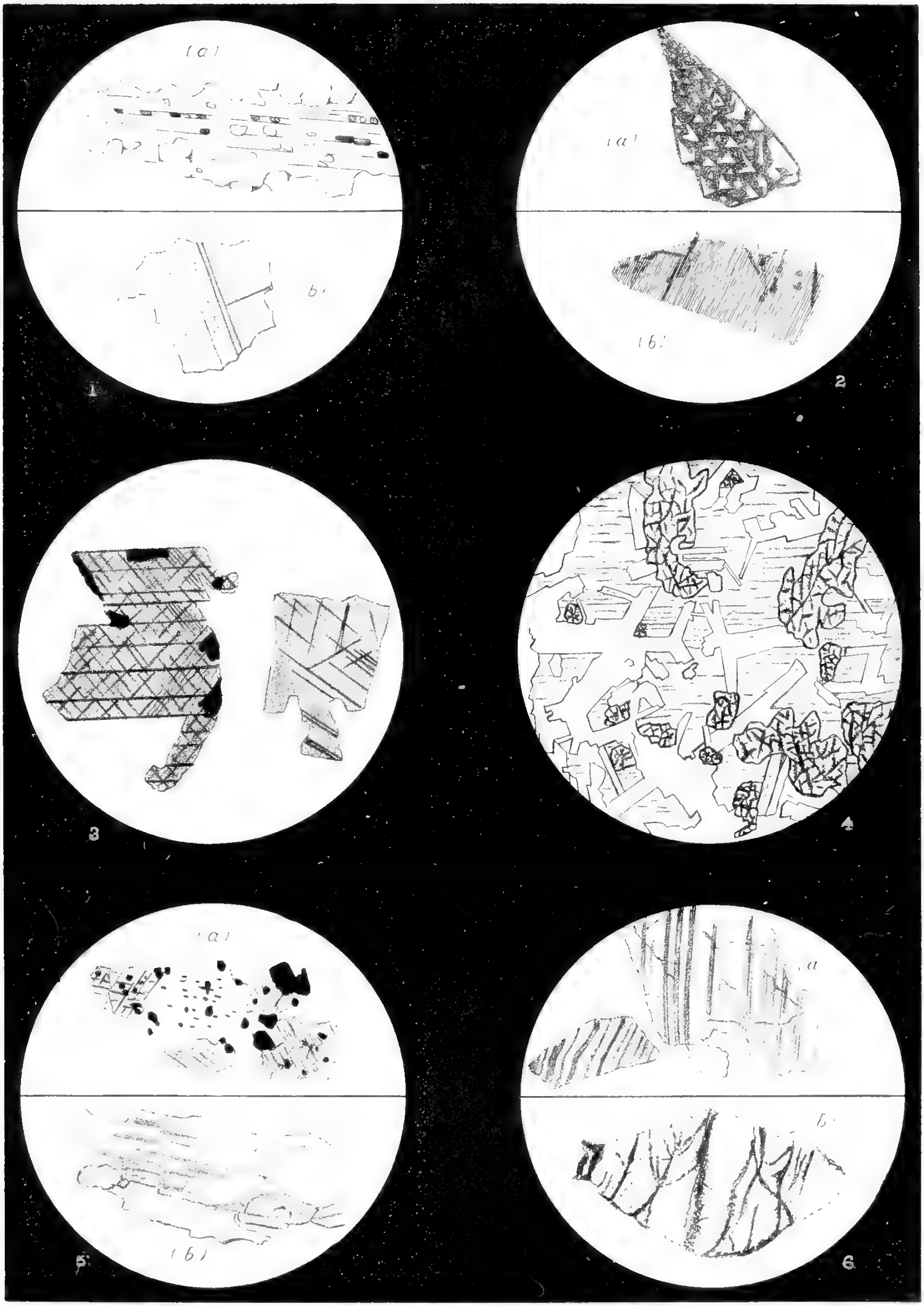


M. P. Parker lith. West Newman imp.

Some Varieties of Central Australian Rocks

PALÆONTOLOGY.

By RALPH TATE, Professor of Natural History in the University of Adelaide.

(WITH PLATES 1, 2, 3.)

LARAPINTINE SERIES (ORDOVICIAN).

1. References to Palæontological Literature of the Larapintine Series.

The discovery of Ordovician fossils in Central Australia is solely due to Mr. F. Thornton, sometime resident at Tempe Downs, who brought some of them to the notice first of Mr. H. Y. L. Brown and afterwards of Mr. C. Chewings, on the occasion of their visits to him in 1890. The first published announcement of this discovery was, however, made by Mr. Chewings (1) antedating Mr. Brown's (2) by a few months.

I.—TATE, R., in Mr. C. Chewings' "Geological Notes on the Upper Finke Basin," Trans. Roy. Soc. S. Aust., vol. xiv., p. 255, 1891, recorded the following genera and species:—*Orthoceras aff. imbricatum* (=Actinoceras tatei, *Eth. fils*), *O. aff. ibex* (=O. ibiciforme, n. sp.), *Raphistoma*, sp. (=R. brownii, *Eth. fils*), *Orthis flabellum* (=O. leviensis, *Eth. fils*), *Strophomena*, sp. (=*Orthis dichotomalis*, Tate), and *Phacops*, sp. (=Asaphus illarensis, *Eth. fils*). The author was of the opinion that the fossils indicated an Upper rather than a Lower Silurian facies.

II.—ETHERIDGE, R., in Mr. Brown's "Reports on Coal-bearing Area in neighbourhood of Leigh's Creek," Parl. Paper, No. 158, 1891, pp. 9, 10, and 13, 14, pl. i., figured and described *Raphistoma brownii*, *Orthis leviensis*, and *Orthoceras*, sp. ind., and believed them to be of Lower Silurian age.

III.—ETHERIDGE, R., in Mr. Brown's "Report on Leigh Creek and Hergott Springs," Parl. Paper, No. 23, 1892, p. 8, pl. i., described and figured *Asaphus* (*Megalaspis*?) *thorntoni.*

IV.—HOWCHIN, W., Trans. Roy. Soc. S. Aust., vol. xvii., p. 355, 1893, recorded the occurrence of sponge-rods, to which he applied Zittel's name of *Hyalostelia.*

V.—Etheridge, R., "A Supplement to Parliamentary Papers," No. 158, 1891, and No. 23, 1892, pp. 1–7, pl. i., 1893, adds *Asaphus illarensis*, *Orthoceras gossei*, *O. tatei*, *Endoceras warburtoni* and *Ophileta gilesi*.

VI.—Etheridge, R., in "Annual Report of the Government Geologist," Parl. Paper, No. 25, 1894, pp. 23–26, pl. iii., figures and describes a third species of *Asaphus*, *A.* (*Megalaspis*) *howchini*, and indicates by figures the occurrence of three species of univalves belonging to uncertain genera, and one of *Ctenodonta*, besides some supplementary information regarding some previously-described species.

2. Fossil Localities.

As already stated, *ante* p. 56, the fossils occur at one definite horizon in the main mass of the Laparatine series, embracing shelly limestones and the immediately underlying sandstones and quartzites. The fossiliferous limestones were observed in Ilpilla Gorge, Middle Valley (from near the junction of the Walker and Palmer Rivers to Shakes Plain), between Petermann Creek and Tempe Downs, Petermann Creek, north-east side of Gill's Range, by camp on Laurie's Creek, and about four miles north (north of Tempe Vale). These localities are on two lines of outcrop of the same beds. Still further north, the same series occupies the lowest level of Horn Valley from Mereenie Bluff to Finke Gorge. The quartzites and sandstone subordinate to the fossiliferous limestones yielded fossils at Middle Valley, Tempe Downs, between Petermann Creek and Tempe Downs, north of Tempe Vale, and Horn Valley at Finke Gorge. Quartziferous sandstone and limestones of Chandler's Range are fossiliferous, as also the quartzites of the Mount Watt outlier. The species of the limestones and of the quartzites are distinct, with the exception of *Orthis dichotomalis* and *Asaphus thorntoni*.

3. Catalogue of the Fossils of the Larapintine Series (Ordovician).

Class Cephalopoda.

Orthoceras gossei, Etheridge, fils.

Ref.—iv., p. 7, pl. 1, figs. 9, 10.

At once distinguished from associated species by the lateral siphuncle and absence of annulations.

Loc.—In limestone, Tempe Downs and Petermann Creek.

Orthoceras ibiciforme, sp. nov. (Plate I., Figs. 7*a*, 7*b*.)

Sp. char.—Shell elongate, straight, rate of increase one in seven; section roundly oblong; surface ornamented with rounded annulations having an obliquity of about 8°. The distance from one annulation to another is one-third the major diameter (in the single example with a test no secondary ornamentation is visible, but as the exterior is somewhat weathered, the presence or absence of sculpture is uncertain). Septa 1·5 mm. apart, where the shell has a major diameter of 15 mm. Siphuncle lateral, but cannot be further described, as in the only specimen containing septa the two septa only visible are broken down around the siphuncle. Body-chamber unknown.

Obs.—This species resembles *O. ibex*, Sowerby, but the annulations are wider apart, as four to three. The cross-section of *O. ibex* seems not to be definitely ascertained, as Blake "Brit. Foss. Ceph," p. 95, says, "it may therefore be naturally elliptical;" whilst Foord "Cat. Foss. Ceph., Brit. Mus.," i., p. 51, on the other hand writes "section circular;" in which latter case the Larapintine fossil is further distinguished by its elliptical section. *Orthoceras*, sp. ind., t. 4, f. 5 in Johnston's Geol. Tasmania, may possibly belong here.

Loc.—In limestone, Middle Valley at Tempe Downs, Petermann Creek.

Orthoceras microlineatum, sp. nov. (Plate II., Figs. 10*a*, 10*b*.)

Sp. char.—Shell elongate, straight, rate of increase one in six; section almost circular. Surface ornamented with slightly elevated, oblique and bisinuate annulations (seven in a length of 17 mm.); sculptured all over with wavy threadlets (invisible to the unaided eye), separated by incised lines (about forty in a width of 5 mm.), which are coincident with the annulations. Siphuncle marginal, large, nearly one-third the diameter of the shell. Septa and body-chamber unknown.

Obs.—This Larapintine fossil is much like *O. duponti*, Barrande, having the same general character of primary and secondary ornament, the excentric siphuncle, and circular section of that species; but the annulations are wider apart, as fourteen to eight, and the microscopic ornament is very much finer and densely crowded. Externally it is distinguishable from *O. ibiciforme* by its circular section and more approximate annulations; in *O. ibiciforme* there are four (nearly) rings in a length of 17 mm., whilst there are seven in *O. microlineatum* in the same length of shell of equal size.

Loc.—In limestone, north of Tempe Vale, Laurie's Creek, Middle Valley at Tempe Downs.

Orthoceras larapintense, sp. nov. (Plate I., Fig. 3.)

Sp. char.—Shell elongate, straight; rate of increase one in ten; section circular. Septa rather deeply concave, sutures slightly bisinuate; the distance between the sutures is about one-tenth the diameter. Siphuncle central, about 2 mm. in diameter. The species is founded on a single specimen, which shows three septal chambers in a length of 8 mm., succeeded by a cylindroid body-chamber 78 mm. long, and 20 mm. and 28 mm. diameters at the proximal and distal ends respectively. The subtending apical angle indicates a shell of about nine inches in length.

Obs.—*O. larapintense* approximates to *O. gossei*, from the same beds, in its narrow septal chambers; but in that species the siphuncle is lateral in position. It resembles also *O. perversum*, Blake, in its narrow septal chambers; but that species has an unsymmetrically placed siphuncle, an elliptic section, and the shell does not taper so rapidly.

Loc.—In limestone, Tempe Downs.

Orthoceras chewingsi, sp. nov. (Plate I., Fig. 1.)

Sp. char.—Shell elongate, straight, rate of increase one in nine, section circular. Septa distant about one-third the diameter, moderately concave, sutures direct. Siphuncle central, about 1·5 mm., where the shell has a diameter of 12 mm. Test and body-chamber unknown. This species is based upon two specimens, the larger of which is a fragment 80 mm. long and 27 mm. diameter at the distal end; it is without septa and siphuncle, though the sutural lines (ten in number) are distinct. The other specimen is nearly complete, except the body-chamber, and measures 80 mm. long; the septa and siphuncle are present. The two specimens I regard as conspecific, because the rate of increase of the shell and the sutural distances are the same.

Obs.—This species agrees with *O. kinnekullense*, Foord, "Cat. Foss. Ceph., Brit. Mus.," p. 2, fig. 1, of the Swedish Ordovician in its circular section and sutural distances, being about the widest known, but it differs from it by its central siphuncle. Orthoceras, sp. ind., t. 4., f. 9, in Johnston's Geol. Tasm., may possibly belong here.

Loc.—In limestone, Laurie's Creek, Petermann Creek, and Tempe Downs.

Orthoceras, sp. Etheridge, fils.

Ref.—vi., pl. iii., figs. 13–15.

I have nothing to add to Mr. Etheridge's description except to observe that the resemblance to *Actinoceras tatei* is very considerable, though the siphuncle is relatively much smaller and the sutures direct.

Endoceras warburtoni, Eth., fils.

Ref.—iv., p. 7., pl. i., figs. 12, 13, and vi., p. 25, pl. iii., figs. 16-20.

Mr. Etheridge in 1894 (4) figured three siphonal casts presumably of this species. I now further supplement this interesting discovery by the pourtrayal of a specimen *in situ* (Pl. II., Figs. 11*a*, 11*b*), though from the greater rate of increase in size of the siphon (one in ten as against one in twenty-three or twenty-four) probably indicates a distinct species. The stoutest specimen has a diameter of 35 mm., and indicates a rate of increase of about one in eleven.

Loc.—In limestone, near camp on Laurie's Creek, north of Tempe Vale, Petermann Creek.

Endoceras arenarium, sp. nov. (Plate I., Fig. 4.)

Sp. char.—Shell straight, section elliptical (the ratio of the two diameters about six to seven), rate of increase about one in seven or eight. Siphuncular cavity included within the septa, marginal, elliptic (the ratio of the two diameters about eleven to twelve), occupying nearly one-half of the longer diameter of the shell. Septal chambers varying from 3 to 7 mm. wide at the circumferential margin, where the longer diameter of the shell is 84 mm. Septa very convex, broadly imbricating exteriorly, and deeply and abruptly descending at the alveolar cavity. Test and body-chamber unknown, though the cast of the septal portion of the shell is smooth.

This species attained to a large size; a portion has the following dimensions: Length, 85 mm.; diameters of the broader end, 84 mm. and 73 mm.; diameters of the narrower end, 75 mm. and 69 mm.; diameters of the siphuncle at the broader end, 33·5 mm. and 18·5 mm. The rate of increase of this and other examples indicates a distal extension of two feet three inches, but a specimen collected at Finke Pass (though not preserved) was quite twice as bulky as the example just quoted. The specimens seem to indicate a distinct species by the elliptic section of the siphuncular cavity.

Loc.—This species is restricted to the quartzites immediately underlying the fossiliferous limestones at north of Tempe Vale and at Finke Gorge.

Actinoceras tatei, Eth., fils., sp. (Plate I., Figs 2*a*, 2*b*.)

Orthoceras, sp. ind., Etheridge, fils (ii.), p. 10, t. 1, fig. 4.

Orthoceras tatei, *id.* (iv.), p. 7.

Obs.—A vertical section of the shell shows that the siphuncle is moderately swollen between the septa. This structure further separates the species from *Orthoceras saturni*, Barr., *O. elevatum*, Hall, and *O. excentricum*, Sowerby, to which it bears a certain external resemblance. The position of the siphuncle is, however, not actually central, as stated by the author of the species. The largest portion obtained has a maximum diameter of two inches, and indicates a distal extension of sixteen inches.

Loc.—This shell occurs in great profusion in limestone near camp on Laurie's Creek and to the north of Tempe Vale, also at Tempe Downs, Petermann Creek, Mereenie Bluff, and Chandler Range.

Trochoceras recticostatum, sp. nov. (Plate I., Figs 5*a*–5*c*.)

Sp. char.—Shell planorbiform with close (though not embracing) whorls. Septa simple, with a slight transverse curvature, about 2·5 mm. apart at the outer circumference of the penultimate whorl. Section of last whorl elliptic; siphuncle external. The ornamentation is obliterated by weathering, except on the back of the last whorl, where it consists of slightly elevated, narrow, straight costæ, separated by shallow interspaces of about one millemetre wide. Test and body-chamber unknown.

Obs.—From the slow increase of the close whorls this shell may be regarded as an immature *Trochoceras* rather than *Gyroceras*, though the asymmetry of its spire is not apparent. It recalls *T. speciosum*, Barrande, but the costæ are more numerous and not retrovert on the back.

Loc.—In limestone, near camp on Laurie's Creek—a unique example.

Class Gastropoda.

Eunema larapinta, sp. nov. (Plate I., Fig. 6.)

Sp. char.—Shell imperforate, pyramidal; whorls three (without apex) of somewhat rapid increase, usually rather broadly and bluntly but occasionally

sharply keeled at about the anterior one-third. In the middle line of the posterior area there is a distinct shallow depression, which, with the revolution of the spire, decreases in conspicuity, and is finally obliterated on the body-whorl. Surface apparently without sculpture. Last whorl somewhat flatly depressed below the bluntly-keeled periphery, thence abruptly sloping to the base. Aperture rhombic-oval, about as wide as high; columella arched in the vertical plane, very convex transversely. Length, 22 mm.; breadth, 16 mm.; aperture, 12 mm. high, 9 mm. wide. A large example of two whorls has a length of 34 mm.

Loc.—In limestone, at Middle Valley, Tempe Downs.

Obs.—The general aspect of this fossil is that of *Eucyclus*, but the columella does not agree with it or other Littorinidæ; it is rather that of Turbinidæ. It also recalls some of the *Pleurotomariæ*, notably the Ordovician *Murchisonia gyrogonia*, McCoy, Brit. Pal. Foss., p. 293, pl. i., k, fig. 43, but the keel on the whorls is not a fascia, and a reference to that genus is not permissable. The imperforate base removes it from *Trochonema*.

Raphistoma brownii, Etheridge, fils.

Ref.—ii., p. 9, pl. i., figs. 1-3.

Obs.—This fossil is abundant in the state of loose casts on the limestone outcrops near camp on Laurie's Creek, north of Tempe Vale, and Petermann Creek. Two specimens show traces of ornament on the underside in the form of oblique growth-lines and slender undulations, which are abruptly retroverted at the keel, and thus indicate the presence of a peripheral sinus; but there is no trace of a fascial band. A large example has the following measures:—Diameters, 90 mm. and 85 mm.; height, 26 mm. The diameter of the umbilicus is about one-third that of the base, but is much lessened with the increasing convexity of the base.

By comparison of an equally-sized specimen of *Raphistoma brownii* with the figure of *Straporollus* (*Macluria*) *tasmanicus*, Johnston, "Geology of Tasmania," pl. v., I am inclined to regard the two as conspecific, but as the base of the Tasmanian shell is not shown it will not be safe to be positive as to their identity. A comparison of actual specimens can alone permit of a definite opinion.

Scalites (?) eremos, sp. nov. (Plate III., Figs. 28*a*, 28*b*.)

Sp. char.—Shell biconic; spire-whorls four, flat, without sculpture or ornament, separated by a linear impressed suture. Body-whorl angulated at the

periphery, beneath which is a narrow, feebly-impressed band; base convex, imperforate, aperture rhombic; columella arched in the vertical plane, very convex transversely. Height, 12 mm.; width, 10·5 mm.; aperture, 6 × 6 mm.

The weathered test does not permit a correct interpretation of the infra-peripheral band; but, in association with the trochiform shape of the shell, is suggestive of *Scalites* rather than *Eunema*.

Loc.—In limestone, Middle Valley at Tempe Downs, Ilpilla Gorge, and at camp on Laurie's Creek.

Ophileta gilesi, Etheridge, fils.

Ref.—v., p. 6, t. 1, figs. 6–8.

The species was founded on a small cast. The shell shows that the three anterior whorls are concave between the keel-like front margin and the suture; the spire is hardly elevated above the last whorl, whilst the apical whorls are sunken; the ornament consists of linear threadlets, oblique, slightly retroverted at the keel, five in a width of one mm., probably indicating a labial sinus, and thus connecting with *Raphistoma*. Dimensions of two largest specimens:—Diameters, 17 mm. and 13 mm.; height, 7 mm.; diameters, 19 mm. and 16 mm.; height, 7 mm.

Loc.—In limestone, camp at Laurie's Creek and north of Tempe Vale.

Pleurotomaria (?) **larapinta**, sp. nov. (Plate III., Figs. 29*a*, 29*b*.)

Sp. char.—Shell depressed conoid, whorls (number ?) subimbricate over the suture. Last whorl with a flange-like keel, narrowly furrowed at the periphery; flatly convex to the suture, narrowly precipitous below the keel, thence flatly convex to the imperforate base. Aperture subquadrate. The ornament consists of revolving threadlets, fifteen in a width of four mm. on the upper surface of the body-whorl, about twenty on the posterior half of the base. Length, incomplete, 12 mm.; width, 13 mm.

Loc.—In limestone, Middle Valley, Tempe Downs.

Imperfectly-known **Euomphaloid** Shells.

(1.) A common fossil in the Larapintine quartzites at Tempe Downs, north of Tempe Vale, between Petermann Creek and Tempe Downs, and also at Finke Gorge, is that indicated by a basal impression, which has been figured by Etheridge, vi., t. 3, figs. 9, 10.

(2.) A second species is represented by internal casts and the impression of the spire; a restoration indicates a shell of the size and general outline of *Euomphalus pentagonalis*, but with a flat inornate spire. It has occurred in sandstone at Chandler Range, and in quartzite between Petermann Creek and Tempe Downs, north side of George Gill Range and at Finke Gorge.

(3.) A third species resembles *Ophileta gilesi* on a large scale; but the spire is more elevated, the upper surface of the whorls flat, and the flange-like keel imbricates over the suture. Only the impressions of the upper surface in quartzite were obtained, though common, at Middle Valley (Tempe Downs), and at north of Tempe Vale.

(4.) A larger shell of the last type is indicated by a similar impression from twenty miles west of Toko Waterhole in Cairns Range, on the Queensland border; it differs in having spiral ridges in addition to the sigmoid growth-folds of the last species.

Class Lamellibranchiata.

Genus **Isoarca**, Münster, 1842.

(*Tellinomya*, Hall, 1847. *Ctenodonta*, Salter, 1852.)

The distinction of *Ctenodonta* (= *Tellinomya*) from *Isoarca*, which was propounded by Salter, viz., that the former had simple curved umbones and the latter subspiral ones, is no longer tenable, as one species of the Larapintine rocks has the umbones more markedly spiral than any described species of *Isoarca* (*sensu stricto*), and therefore I adopt Woodward's opinion that *Ctenodonta* is synonymic with *Isoarca*.

I cannot formulate any set of characters, based on shape, direction of hinge, disposition and form of teeth, by which the Mesozoic and Palæozoic species may be kept in different genera; indeed, if such a course were followed, it would be necessary to establish several genera for the Larapintine species alone. The phrase "Nucula or Leda-like shells" has not a universal application, as may be judged from the various species herein illustrated, not one of which resembles either *Nucula* or *Leda*; but associated with the dentition of *Isoarca* there is represented the form of *Pectunculus*, *Arca*, *Opis*, *Crassatella*, *Modiola*, etc.; whilst an extreme divergence to an orbicular outline is presented by *I. orbicularis*.

Isoarca etheridgei, sp. nov. (Plate II., Fig. 15).

Ctenodonta, sp., Etheridge, f., vi., p. 24, t. 3, figs. 6-8.

Sp. char.—Oval-trigonal, inequilateral, umbones anterior and directed forwards; moderately convex, posterior margin roundly truncated, ventral margin nearly straight, anterior margin shortly rounded, post-dorsal region depressed. Hinge-line steeply inclined and straight posteriorly; less declinous and slightly curved anteriorly; teeth numerous, small, regular and transverse, thirty on the posterior side and ten on the anterior side. Surface of shell marked by strong folds of growth and coincident striæ. Diameters, umbo-ventral, and antero-posterior, 20 mm.; sectional, 11 mm. Mr. Etheridge's figures represent a more oblong shell than my type, and connects with a still more oblong variety, but the trigonal form is the more common.

Loc.—In limestone, Middle Valley at Tempe Downs, Petermann Creek, by camp at Laurie's Creek, north of Tempe Vale, and Chandler Range.

Isoarca eastii, sp. nov. (Plate II., Figs. 12*a*, 12*b*).

Sp. char.—Shell transversely oval-oblong, very inequilateral, umbones almost terminal; inflated dorsally and medially, somewhat compressed antero-ventrally; posterior margin roundly truncated, ventral margin nearly direct but rapidly curving upwards to the anterior margin; hinge-line slightly arched and long on the posterior side, short and almost perpendicular on the anterior side. Hinge-teeth transverse, arched, regularly disposed, increasing in size from the umbo outwards, about seven on the anterior side and about fifteen on the posterior side. Cast smooth, the anterior adductor scar large and deep. Antero-posterior diameter, 44 mm.; umbo-ventral diameter, 32 mm.

Var. **modiolæformis** (Pl. II., fig. 12*b*) differs by its obliquely cylindrical shape and more prominent umbos, but is connected with the type by intermediate gradations. The cast presents a few growth-lines and fine coincident striæ.

Loc.—In sandstone and quartzite underlying the fossiliferous limestone at Middle Valley (Tempe Downs).

Isoarca corrugata, sp. nov. (Plate I., Fig. 8.)

Sp. char.—Shell small, transversely oval-oblong, inequilateral, moderately convex; umbones ante-median, incurved, approximate. Anterior side short and rounded; ventral margin slightly ecurved medially; posterior side about twice as long as the anterior one, slightly narrowing towards the subtruncate margin; post dorsal margin straight declinous, antero-dorsal margin slightly concave. Hinge line with direct, transverse, uninterrupted, close teeth, with narrower interstitial

sockets, about fifteen on the posterior side and six on the anterior side (but the actual number may probably be ten; the hinge-line on the anterior side is incomplete in the only specimen showing this part of the interior). Surface ornamented with about eight strong corrugations and nearly a direct post-umbonal ridge. Antero-posterior diameter, 6 mm.; umbo-ventral diameter, 4 mm.

Loc.—Thickly covering the limestone surfaces at Middle Valley (Tempe Downs), also Ilpilla Gorge.

Isoarca orbicularis, sp. nov. (Plate II., Figs. 18*a-b.*)

Sp. char.—Shell orbicular, moderately convex, without ornament; umbo subspiral, large, depressed, obtuse, far-distant from the dorsal margin, almost subcentral; the anterior dorsal margin is arched upwards to become adnate with anterior part of the hinge-area, thus simulating *Exogyra* or the operculum-like valve of a *Requienia*. Hinge-teeth occupying a semi-elliptic curve, coincident with the post-dorsal margin of the shell, but receding more and more from the antero-dorsal margin of the shell towards its anterior extremity. Teeth numerous and closely-set; on the extreme posterior side they are curved, thence becoming more and more directly transverse and smaller, and finally almost obsolete on reaching the anterior adductor scar. Adductor scars inconspicuous. Antero-posterior diameter, 23 mm.; transverse diameter, 20 mm.

Loc.—Abundant in quartzite at Mount Watt.

Isoarca crassatellæformis, sp. nov. (Plate II., Fig. 19.)

Sp. char.—Shell transversely suboval or subtrapezoidal, subinequilateral; anterior side rounded; ventral margin nearly straight, with a moderately deep insinuation post medially; posterior margin obliquely truncated, the dorsal margin about equally sloping on each side. Umbones moderately inflated, submedian (a little anterior); posterior area defined by a subcarination extending from the umbo to the post-ventral margin. Hinge-line with numerous small, transverse teeth. The surface of the shell, anterior to the posterior carination, is ornamented by wide, convex folds (about twelve) separated by linear sulci coincident with the anterior and ventral margins. Inner margin of valves edentulous. Antero-posterior diameter, 18 mm.; umbo-ventral diameter, 12 mm.; greatest sectional diameter, 9 mm.

Loc.—Numerous in quartzite with *I. orbicularis* at Mount Watt.

Obs.—This fossil presents a remarkable analogy to *Crassatella sulcata* of the Eocene of Paris and Barton.

Isoarca opiformis, sp. nov. (Plate II., Figs. 16*a*, 16*b*.)

Sp. char.—Cast quadrate, with a very large, strongly curved, sub-central approximate beak; the steep posterior slope is demarked by an elevated keel extending from the umbo to the post-ventral margin; the anterior side depressed and projects forwards; its margin is rounded. Hinge-line arched; teeth transverse and direct, about six on the anterior side, about twenty smaller ones on the posterior side. The test must have been very thick, at least anteriorly, judging from the large conical cast of the anterior adductor impression. Diameters:—Antero-posterior, 20 mm.; umbo-ventral, 18 mm.; sectional, 18 mm.

Loc.—In quartzite, between Petermann Creek and Tempe Downs.

The only important variation in shape exhibited by this species is in the width of the posterior area; when at its shortest the umbonal keel hides it when viewed from above. An extreme form has that area wider, therefore not so steep and so concealed from view by the umbonal carination. The species name is in allusion to the external resemblance this fossil has to some species of *Opis*, *e.g.*, *lunulatus*.

Isoarca wattii, sp. nov. (Plate II., Figs. 17*a*, 17*b*.)

Sp. char.—Cast oval-oblong to cuneiform, with very large, strongly curved, sub-marginal, approximate umbones, rounded in front and attenuated behind; ventral margin straight, post-dorsal margin arched. The post-dorsal area is declinous, arising from the umbonal ventricosity extending to the post-ventral angle, so much so that the hinge-line is posteriorly hidden when the cast is viewed from above. Teeth as in *I. opiformis*, few and large anteriorly, numerous and smaller posteriorly. Diameters:—Antero-posterior, 25 mm.; umbo-ventral, 16 mm.; a large example, 32 mm. by 20 mm.

Loc.—In quartzite between Petermann Creek and Tempe Downs, associated with *I. opiformis*, from which it differs by its cuneiform shape.

Palæarca wattii, sp. nov. (Plate II., Fig. 14.)

Sp. char.—Shell transversely oblong to obliquely rhomboid, moderately ventricose; umbones almost marginal, incurved and approximate; anterior much narrowed; posterior side much expanded, obliquely truncated. Surface of cast marked by

fine growth-lines, particularly on the post-dorsal area. Hinge-area narrow, with three parallel, longitudinal, slightly arched teeth posterior to the umbo; anterior teeth two, parallel. Dimensions of figured specimen, which is of small size:—Antero-posterior diameter, 36 mm.; umbo-ventral diameter, 21 mm.; greatest dorso-ventral width near to the posterior margin, 27 mm. A very large example measures 60 × 30 mm.

Loc.—In quartzite and sandstone, Tempe Downs, north of Tempe Vale, and Finke Gorge.

Obs.—This species has some resemblance to the Ordovician species, *P. billingsiana*, Salter, and *P. headi*, Billings, in its arca-like shape, but is distinguished by its submarginal umbo and dilated post-dorsal area; but it apparently exactly resembles *Modiolopsis truncatus*, Hall, from beds of corresponding in Ohio and New York, judging from the figure of that fossil on pl. ii., fig. 13, in Report Geol. Surv. Ohio, vol. ii., p. 86, 1875.

Palæarca tortuosa, sp. nov. (Plate III., Fig. 31.)

Sp. char.—Cast triangularly trapezoidal in form, rapidly widening posteriorly; axis oblique, corresponding with a high vaulted angulated ridge from the umbo to the postero-basal angle, on each side of which the slope is precipitous, more so dorsally than ventrally. Hinge-line straight, umbo at about the anterior one-sixth; hinge-area of moderate width, marked by two parallel and longitudinal teeth, which extend for the whole length of the posterior side. Anterior side of shell somewhat wing-like dorsally; posterior margin nearly perpendicular to the hinge-line. Surface of the cast marked by faint folds, which are slightly sigmoid on the umbonal ridge. Length of hinge-line, 23 mm.; of umbonal ridge, 26 mm.; of posterior margin, 16 mm.

Loc.—In quartzite, Mount Watt and between Petermann Creek and Tempe Downs.

Pteronites micans, sp. nov. (Plate I., Fig. 9.)

Sp. char.—Shell transversely elongate, narrow lanceolate; hinge-line straight; beak small, nearly terminal; anterior very short and narrowly triangular; posterior side truncate; surface with six equidistant radial ridges. The cast of the hinge-line presents a narrow parallel ridge terminating anteriorly at a small pit, which may be interpreted to indicate a long cartilage furrow posterior to a cardinal tooth. But for these characters the fossil might have been mistaken for

Hyolithes. Total length of hinge-line, 9 mm.; umbo, 1·5 mm. from the front; width of posterior margin, 3 mm.

Loc.—In limestone, Tempe Downs.

Conocardium, sp. ind. (Plate II., Fig. 13.)

The fossil here represented is a cast, which by its shape may possibly be referable to *Conocardium*.

Loc.—In limestone, Tempe Downs.

Class Brachiopoda.

Orthis leviensis, Eth., fils.

Ref.—ii., p. 13, t. 1, figs. 5–7; v., p. 6, t. 1, figs. 2–5.

Loc.—In limestone, Ilpilla Gorge, Middle Valley, Petermann Creek, Laurie's Creek, north of Tempe Vale, Mereenie Bluff, and Horn Valley.

Orthis dichotomalis, sp. nov. (Plate II., Figs. 20*a–d*.)

Sp. char.—Shell semicircular, about twice as wide as long, the greatest width at the long straight hinge-line; cardinal extremities prolonged into acute, angular, mucronate wings; valves concavo-convex. Ventral valve slightly concave, with a deep depression along the middle, flanked on each side by a slight radial depression; umbo sharp, pointed, but not prominent. Dorsal valve moderately convex, with a median elevation, flanked on each side by a slight radial elevation; umbo insignificant and depressed. Hinge-line linear, concave, angular, sculptured with parallel incised lines. Fissure rhombic, divided medially by the obtrusion of the cardinal process of the dorsal valve, partially arched over by a pseudo-deltidium adnate to each umbo.

The ornament consists of slender radial threadlets, increasing in number by successive dichotomising, about five in a width of 1 mm. at the medial front margin; the interspaces are crossed by fine distant growth-lines. Length, 16 mm.; width, 30 mm.; sectional diameter, 3·5 mm. A very large specimen has length 17 mm., width 35 mm.

Loc.—Abundant in limestone, at Laurie's Creek, also at Petermann Creek, north of Tempe Vale, and Mereenie Bluff; in quartzite, north of Tempe Vale.

Obs.—This species I had originally regarded as a *Strophomena*, allied to *S. funiculata*, McCoy (I.), but despite its *Strophomena*-like outline and the partial closure of the foramen, yet by its internal characters it must be referred to *Orthis*, among species of which it presents certain analogy to *O. alata*, Sow., and *O. philipi*, Davidson, differing from both by its crowded radial ornamentation. The concavo-convex valves separate it from the alate Strophomenæ with semicircular outline, *e.g.*, *funiculata*, *pecten*, and *applanata*.

Class Crustacea.

Order Trilobita.

Asaphus thorntoni, Eth., fils.

Ref.—iii., p. 8, pl. ii., 1892.

Loc.—In limestone and quartzite, Middle Valley, Tempe Downs.

Asaphus illarensis, Eth., fils. (Plate III., Figs. 21*a*, 21*b*.)

Ref.—v., p. 5, pl. i., fig. 1.

Perhaps the most important palæontological discovery made by the Expedition is that of an entire trilobite, as hitherto these fossils had only been known by pygidia and a few fragments of the thorax. The specimen herein figured removes any doubt which may have been entertained as to the generic location of the tail-piece on which Mr. Etheridge established his *Asaphus illarensis*.

The facial suture is proper to *Asaphus*, but in this species proceeds almost direct from the eye to the front margin. There are seven thoracic segments, but as the specimen is broken at the seventh segment and the tail forced back, it is possible that the eighth segment had become detached.

Head, thorax and tail of about equal length. Glabella clavate. Thorax of seven (eight?) segments; the axis as wide as the pleuræ, very convex, slightly tapering, nearly parallel-sided; pleuræ nearly straight, flattened, slightly produced and bent down at their ends, grooved throughout.

Total length, 62 mm.; greatest width, 40 mm. This species does not seem to have attained so large a size as some of its congeners; but a specimen consisting of six thoracic and pygidium has a length of 46 mm., corresponding to a total length of 80 mm.

Loc.—In limestone, camp at Laurie's Creek, north of Tempe Vale, Mereenie Bluff, and Petermann Creek.

Asaphus howchini, Eth., fils.

Ref.—vi., p. 23, t. 3, fig. 1.

A thoracic somite (the axis of which is wider than the pleuræ), evidently belonging to this species, has a total length of 80 mm., thus indicating a size equal to that of *A. tryannus.*

Loc.—In limestone, camp at Laurie's Creek and north of Tempe Vale.

Asaphus lissopeltis, sp. nov. (Plate 3, Figs. 24, 25, 26.)

Sp. char.—Tail rather more than a semicircle, smooth, with a depressed border. The axis is very distinct, tapers rapidly, and gradually becomes obsolete just within the depressed border; the upper one-third is faintly annulated. The sides in the upper one-third have four faint ribs, the rest of the surface is smooth. Greatest width, 48 mm.; axial length, 32 mm.

I figure a glabellum that may belong to this species, which differs from that of *A. illarensis* by the somewhat semicircular track of the facial suture. In association with it is a cheek-piece, which differs by its long attenuated backward extension.

Loc.—In limestone, camp at Laurie's Creek and Petermann Creek.

Obs.—This pygidium approaches that of *A. illarensis* in shape, but differs, *inter alia*, by the obsolete segmentation.

Hypostomes of Asaphus, spp. (Plate III., Figs. 22, 23.)

The hypostome figured and described by Mr. Etheridge, vi., p. 23, t. 3, fig. 2, has been redrawn (Fig. 23), after freeing the anterior part from its covering matrix; it now presents a very different appearance in its anterior margin, which is excessively prolonged and winged. Judging from the matrix, the specimen came from the limestone on Laurie's Creek, and in all probability belongs to *Asaphus howchini.*

Another labrum (Fig. 22) represents a different type; it was obtained at Middle Valley, Tempe Downs, and may have belonged to *Asaphus illarensis.*

Class Echinodermata.

The separate joints of slender crinoid stems are not infrequent on the surfaces of the limestones in Middle Valley, and have also been observed in the same beds on the north side of George Gill Range. The fragment of stem figured (Fig. 27*a*) has a diameter of three mm., and consists of twenty-three joints in a length of eight mm. An articular face is shown in Fig. 27*b*.

Class Zoantharia.

Two species of corals occur in the limestones at Middle Valley and George Gill Range. One consists of a cylindrical stem with simple forked branches; the other forms explanulate thin crusts. They may belong to *Chætites*, but the condition of the specimens does not permit of microscopic analysis, and therefore the generic position is indeterminable.

Class Spongida.

The presence of sponge-rootlets in the Larapintine siliceous beds has already been recorded by Mr. Howchin (iv.). Moreover, the quartzite at Finke Gorge is penetrated through a vertical thickness of four inches by cylindrical casts of about 1·5 mm. in diameter; and though the casts are larger than *Hyalostelia* rods usually are, yet it is more probable that they are so than annelide burrows.

4. Correlation.

By the presence of *Endoceras* and *Asaphus*, as well as by the affinities of many of the Molluscan species, it may safely be concluded that the fauna is Ordovician; whilst the remarkable preponderance of *Isoarca* imparts a local feature. Hitherto the only known Ordovician fauna in Continental Australia is that of the auriferous graptolite slates of Victoria; but that fauna is almost entirely composed of Graptolites, and is not in any way comparable with that of the Larapintine rocks. Diligent search was made for Graptolites in the large development of argillaceous beds towards the base of the Larapintine Series in Stokes Pass, but without success.

The question naturally arises, are the Larapintine beds and the Victorian graptolite slates contemporaneous, or, if not, what is their relative position? The answer is supplied by the sequence of the faunas in the Ordovician System in Tasmania.

There are recognised two groups of rocks,* (1) The "Auriferous Slate Group" in the north-east, and (2) "The Gordon River Group." These two groups do not come in contact, but from fossil evidence the Gordon Group is considered to succeed the former. The Auriferous Slate Group contains the remains of graptolites and a small species of *Orthis*, and it may tentatively be regarded as the equivalent of the Graptolite Slates of Victoria.

The facies of the Molluscan fauna and the lithological characteristics of the Gordon River Group are in accord with the Larapintine Ordovician, and in marked contrast with the Victorian type. The absence of Trilobites, which serve to fix the age of the Larapintine beds, and other salient forms in the Gordon River Group, may raise a doubt as to their synchronism. As to whether the Gordon River Group and the Larapintine Series exhibit any closer affinity in their faunas than is indicated by the generic grouping of their mollusca cannot be ascertained except by comparison of actual specimens. With few exceptions the fauna of the Gordon River Group has not been diagnostically made known. Mr. Johnston has, however, on plates iv., and v., *op. cit.*, figured fourteen species, and attached specific names to six of them; but, being undescribed, it is doubtful if any specific identifications are possible, either from the imperfection of the portraitures or by the omission of characters necessary to their correct classifactory position. Nevertheless the resemblances which some of the Larapintine fossils bear to the less indistinct of Mr. Johnston's figures lead to the belief that a considerable community in species will eventually be found to obtain.

The proofs are not conclusive, but there is presumptive evidence that the Gordon River Group and the Larapintine Series are cotemporaneous and younger than the Victorian Graptolite Slates. Mr. Johnston, *op. cit.*, p. 51, inclines to regard the Gordon River Group as the equivalents of the Caradoc Series of England. So do I in respect of the Larapintine Ordovician, not so much because of its cotemporanity with the Gordon River Group, but rather because of its representative fauna.

DESCRIPTION OF PLATES.

PLATE I.

Fig. 1.—*Orthoceras chewingsi*, n. sp. Natural size.

" 2.—*Actinoceras tatei*, Eth., f. *a*, natural section, showing septa and siphuncle; *b*, end view of septal surface.

* Johnston, "Geol. Tasmania," pp. 52-63.

Fig. 3.—*Orthoceras larapintense*, n. sp. Natural size.

„ 4.—*Endoceras arenarium*, n. sp. End view of septal surface.

„ 5.—*Trochoceras recticostatum*, n. sp. *a*, portion of two whorls, the inner shewing septa; *b*, section of outer whorl; *c*, dorsal aspect of outer whorl.

„ 6.—*Eunema larapinta*, n. sp. Slightly enlarged.

„ 7.—*Orthoceras ibiciforme*, n. sp. *a*, a cast, natural size; *b*, end view of septal surface of another specimen, with test preserved.

„ 8.—*Isoarca corrugata*, n. sp. × 3.

„ 9.—*Pteronites micans*, n. sp. × 3.

Plate II.

Fig. 10.—*Orthoceras microlineatum*, n. sp. *a*, siphuncular aspect; *b*, magnified portion of test.

„ 11.—*Endoceras*, sp. Siphuncle, partially embraced by the septa. Siphuncular and opposite aspects, *s*., siphuncle, *sp*., septal chambers.

„ 12.—*Isoarca eastii*, n. sp. *a*, type, natural size; *b*, var. modiolæformis, natural size.

„ 13.—*Conocardium*, sp. ind.

„ 14.—*Palæarca wattii*, n. sp. Natural size.

„ 15.—*Isoarca etheridgei*, n. sp.

„ 16.—*Isoarca opiformis*, n. sp. *a-b*, casts of two examples.

„ 17.—*Isoarca wattii*, n. sp. *a*, front view of cast; *b*, dorsal aspect of the same.

„ 18.—*Isoarca orbicularis*, n. sp. *a*, cast slightly enlarged; *b*, wax-impression of exterior mould.

„ 19.—*Isoarca crassatellæformis*, n. sp. Wax impression of exterior mould.

„ 20.—*Orthis dichotomalis*, n. sp. *a* and *b*, dorsal and ventral valves; *c*, hinge-line; *d*, section of the closed valves.

Plate III.

Fig. 21.—*Asaphus illarensis*, Eth., f. *a* and *b*, anterior and posterior parts; *c*, end view.

„ 22.—Hypostome of an *Asaphus* (*A. illarensis?*).

„ 23.—Hypostome of an *Asaphus* (*A. howchini?*).

Fig. 24.—Pygidium of *Asaphus lissopeltis*, n. sp.

,, 25.—Glabellum of *Asaphus lissopeltis ?*

,, 26.—Cheek-piece of *Asaphus lissopeltis ?*

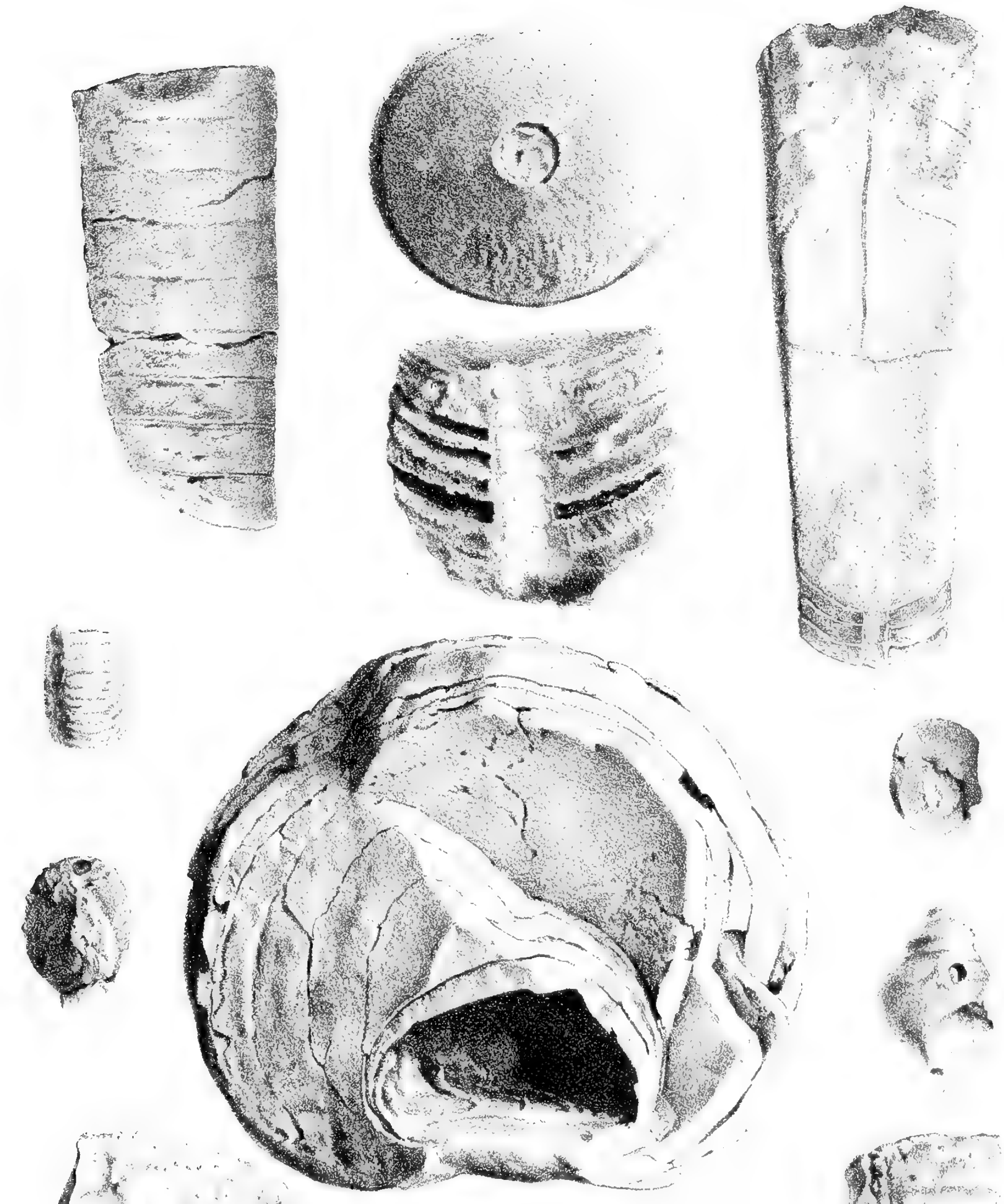
,, 27.—Crinoid. *a*, side view of a portion of column enlarged ; *b*, articular face of a joint.

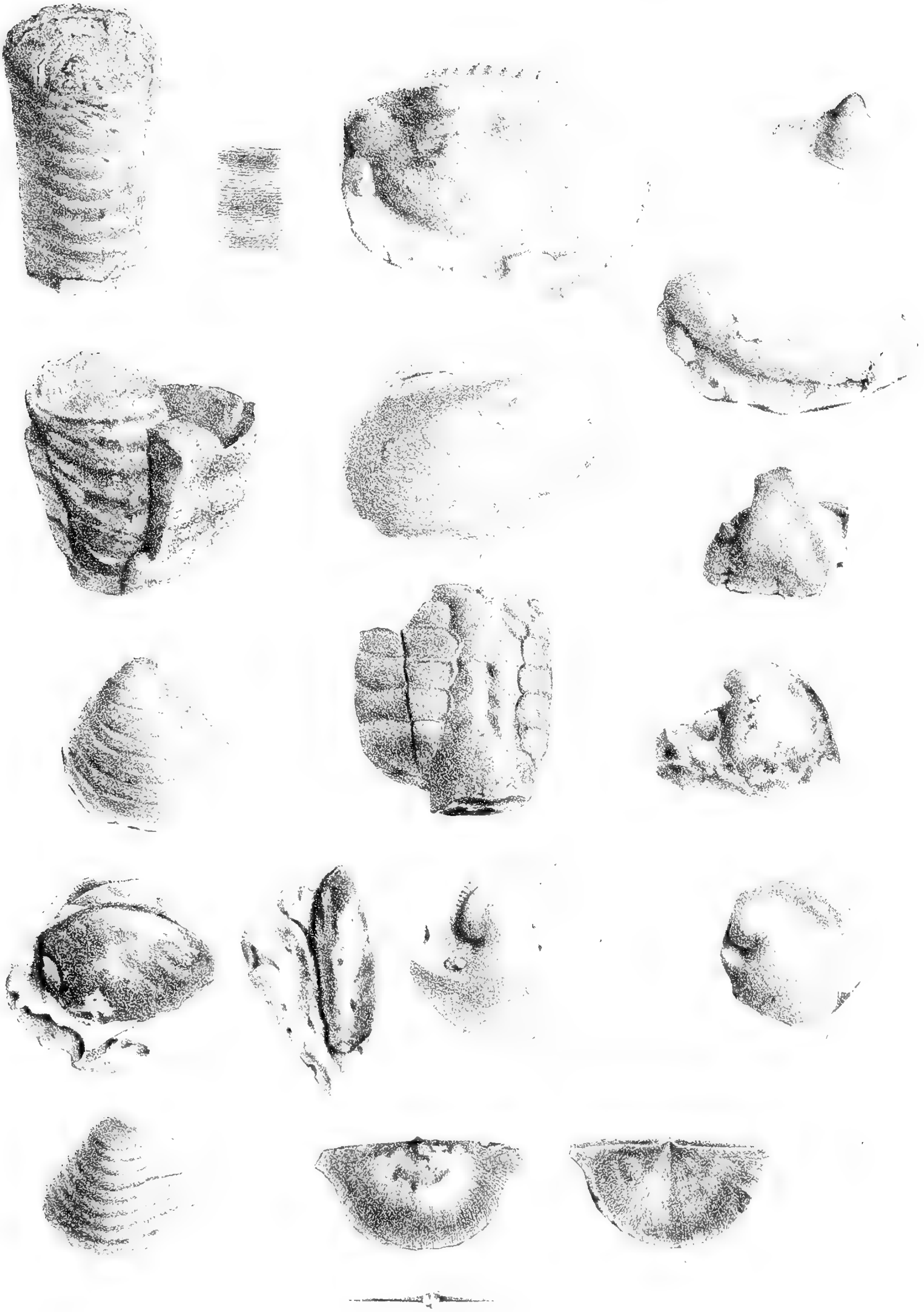
,, 28.—*Scalites* (?) *eremos*, n. sp. *a* and *b*, back and front views enlarged.

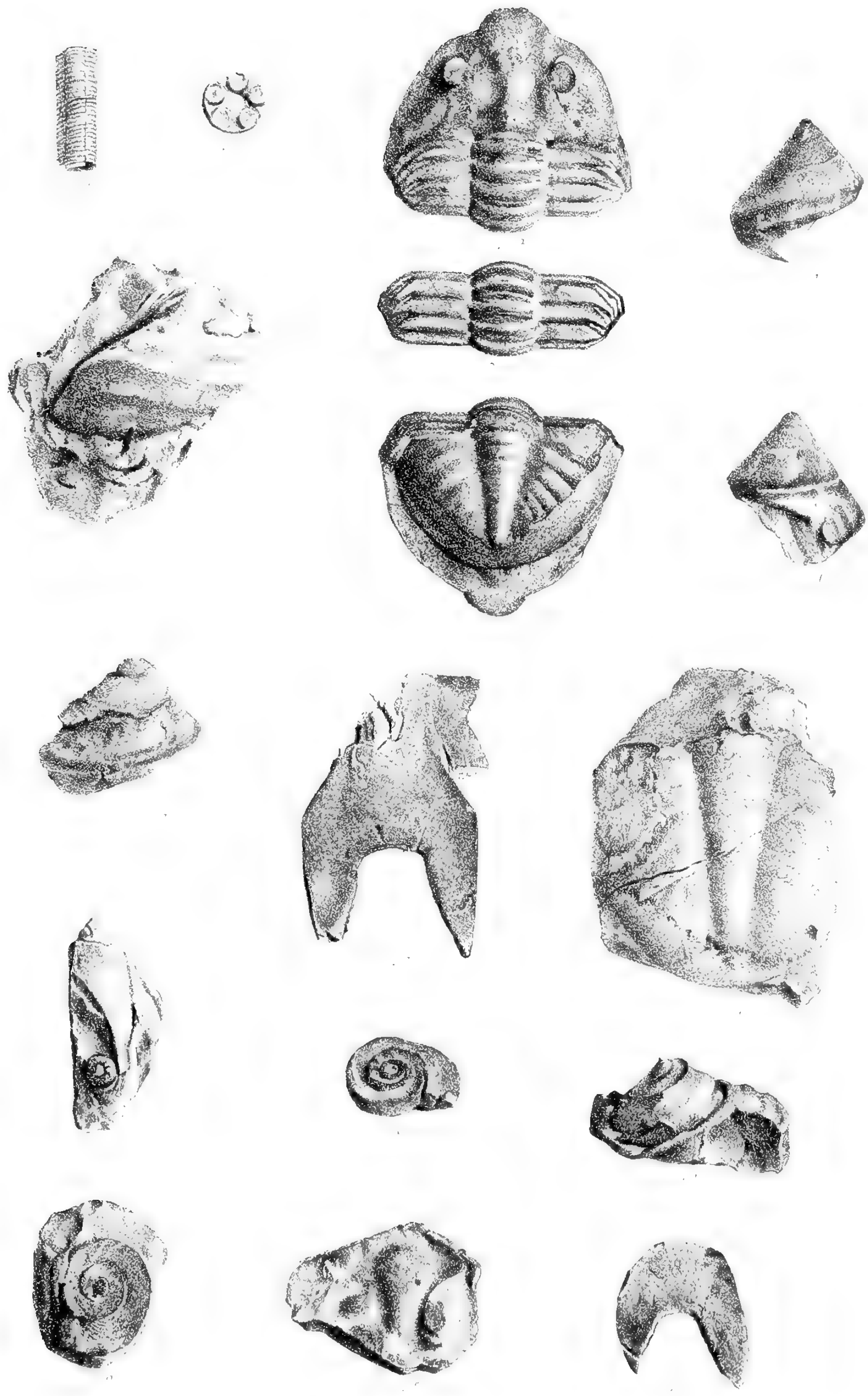
,, 29.—*Pleurotomaria* (?) *larapinta*, n. sp. *a* and *b*, front and back views enlarged.

,, 30.—*Ophileta gilesi*, Eth., fil. *a*, seen from above ; *b*, oblique view to show excavated surface of spire-whorls.

,, 31.—*Palæarca tortuosa*, n. sp.







BOTANY.

By RALPH TATE, Professor of Natural History in the University of Adelaide.

With an Appendix by J. H. Maiden, F.L.S.

CONTENTS.

Chapter I.—The Larapintine Flora.

1. General Physiography and Boundaries of the Larapintine Region.

In my arrangement of South Australian Plants, in "A Handbook of the Flora of Extratropical South Australia," Adelaide, 1890, I have demarked the area occupied by the Eremian flora and its subdivisions; therein the northern and central regions are separated from each other by a latitudinal line through Charlotte Waters. On physiographic grounds this is a good line, as up to the River Coglin the dominant feature is that of stony table-lands of Cretaceous rocks, which, though not ceasing there, continue further north, but only as small outliers

with extensive intermediate low-level areas covered with loose detritus. Now, as the result of personal knowledge of the country, I propose to shift the boundary to the latitude of Engoordina, which will accord better with physiographic and botanic contrasts.

To the north of this latitude the prevailing feature is a table-land of Ordovician sandstone of an average elevation of 2500 feet, which rises from a base of about 1000 feet, gradually increasing to the northward to about 2000 or more feet. This table-land is eroded in long parallel east and west valleys of varying width, from a few chains to several miles, whilst the river channels break through the intervening tabular ridges here and there to connect one valley with another in deep narrow precipitous gorges. This is the area which I name LARAPINTINE, from the native name, *Larapinta*, of the upper and middle Finke River.

On structural and botanical grounds I extend the region to include the southern watersheds of the Levi and George Gill Ranges, and the northern and western drainages which originate from the western extremity of the Mereenie Escarpment and its westerly extensions. This region is bounded on the south-east by remnants of the Cretaceous table-land, and further west by the depressed area centering in Lake Amadeus; on the north the Larapintine table-land abuts on and partially enters into the conformation of the McDonnell Range (*sensu stricto*, as deliminated by Stuart), which forms the southern boundary to the elevated plain called Burt Plain. The route traversed by the main body of the Expedition practically circumscribed the Larapintine region. To the eastward of the meridian of Alice Springs the characteristics of the Larapintine basin are much modified by more extensive erosion and change in rock-structure, which, in conjunction with greater aridity, produce a flora much less varied than that of the western section.

2. BOTANICAL CHARACTERISTICS.

(*a*) *Introduction.*—The notions of the generality of people as to the physiography and geology of this region of Central Australia prove to be vague in the extreme. What I had gathered from books and personal statements led me to give such play to my imagination that I had pictured a vast mountain system capable of preserving some remnants of that pristine flora which existed on this continent in Paleocene times—probably a beech, possibly an oak, elm, or sycamore. It was because of such considerations that I drew attention in my Inaugural Address at the Adelaide meeting of the Australasian Association for the Advancement of Science, 1893, to the desirability of a systematic exploration of the oasis of the McDonnell Range. The awakening came suddenly and rudely, as there

exist no such features as could possibly maintain, under existing conditions, a fauna or flora of a sub-alpine or cold temperature clime; the region lacks even those combinations to modify to any extent its species. Nevertheless the region is not without interest; indeed one cannot escape the conviction that its *endemic* flora is in a state of decadence, and is being supplanted by an aggressive vegetation, exotically derived. Moreover, its physiography is unique and on a grand scale.

Having thus little hope of the discovery of botanical novelties, also because of extensive botanical explorations previously made, I determined very early on the journey to concentrate my efforts in the direction of studying the facts and problems of geographic distribution. The geographic references of many of the recorded species had to be revised, as such locations as "between the Alberga and McDonnell Range," "between Lake Eyre and Alice Springs," and others, are too vague to be of special value; whilst another discordant factor, happily less frequent of late, is that which attributes the locality of a plant to the place whence the specimen was transmitted to the recorder.

(*b*) *Salient Botanic Features of the North Eremian Region.*—The dominant feature of the Central Eremian region is the prevalence of salsolaceous plants, especially over the stony plains and loamy flats; in the Larapintine region they are replaced by grasses, and of these a species of *Triodia* ("porcupine grass" or, incorrectly, "spinifex" of explorers and residents) dominates sandy ground and the sterile slopes and tops of the sandstone table-lands. The arboreous vegetation is represented by *Casuarina Decaisneana* (desert oak), *Grevillea striata* (silky oak), *Brachychiton Gregorii*, *Ficus platypoda*, *Eucalyptus terminalis*, *E. Oldfieldii*, *Canthium latifolium*, *Livistona Mariæ*, *Encephalartos Macdonnelli* and others, which are either restricted to the region or do not pass beyond its southern boundary. *Acacia Farnesiana*, *Atalaya hemiglauca*, *Eucalyptus tessellaris*, and *E. gamophylla* are prevalent, though they reach into the northern parts of the Central Eremian region. *Cassia eremophila* and *Eucalyptus microtheca*, which are very characteristic of the central region, are largely replaced in the northern one by *C. phyllodinea* and *E. rostrata* respectively.

(*c*) *The Lowland Vegetation.*—This comprises that of the river-banks, the loamy plains and sandy ground. It consists, in the greater part, of species widely diffused throughout the Eremian region, extending far south in South Australia, eastward into New South Wales and South-west Queensland, and westward to the shores of mid Western Australia. This portion of the Larapintine flora offers considerable similarity to that of Shark's Bay, as enumerated by Baron F. von

Mueller (Parl. Report, Perth, 1883); thus, of a total of 332 species, deducting therefrom ten which are maritime, 187, or 60 per centum, are constituents of the flora of the Finke Basin; and by very slight extension of that area the actual number in common is 198. The Orders Zygophylleæ, Malvaceæ, Salsolaceæ, Leguminosæ, Myoporineæ, and Gramineæ, which are most largely represented, have few species which are not common to the two areas. The Myrtaceæ of all others show the greatest specific distinctness; thus, of seventeen inhabiting Shark's Bay, only three are in common, viz., *Eucalyptus terminalis*, *E. eudesmoides*, and the ubiquitous *E. rostrata*. So also the flora of Nickol Bay exhibits the same affinity, as, of a total of 185 species listed by Baron F. von Mueller (Parl. Rep., Perth, 1881), 110, or 60 per centum, occur in the Larapintine region.

This type of vegetation constitutes a very large proportion of the whole Larapintine flora; its species are either immigrants from the Oriental Botanical Province or are endemic species of extra-Australasian genera. The truly Australian forms, excepting perhaps among *Acacia*, *Eucalyptus*, and a few others, are most frequently gregarious in isolated colonies, sometimes occupying a few square yards, or even as much as several square miles. Of the former, *Diplopeltis Stuartii*, *Catosperma Muelleri*, and *Ptychosema trifoliolatum* may be quoted as examples, and *Brachysema Chambersii* and *Grevillea eriostachya* of the latter. On several occasions, in the earlier part of our travels, I had passed by an unfamiliar plant, hoping it would extend as far as our halting-place, near approaching; but in the majority of instances the expectation was not realised. Profiting by this experience, I afterwards let no plant unknown to me go ungathered. It is because of the sporadic distribution of many of the Australian species that it is probable that a not inconsiderable number remain to be discovered.

The aggressive nature of the alien plants is exhibited not only by their extensive distribution, but also by their ability to adapt themselves to extremes of soil and climate. Such species, among others, as *Tribulus terrestris*, *Cleome viscosa*, *Malvastrum spicatum*, *Boerhaavia diffusa*, *Salsola kali*, *Mollugo hirta*, and *Pollichia Zeylanica* range from the river-banks and loamy plains to the sandhills, and surmount the highest elevations of the rocky country. No endemic species shows such ubiquity, not even *Triodia pungens*, which seems confined to absolutely sterile tracts, no matter however great the elevation. *Chenopodium rhadinostachyum*, though not a common plant, has however an equal altitudinal range.

(*d*) *The Saxatile Vegetation.*—I cannot write of a mountain flora because the number of actual species on the table-lands and other high-level tracts is absolutely few. The exploration of Station Range, of about 500 feet elevation above Tempe

Downs and 2179 feet above sea-level, which forms the south boundary of the valley of the Walker River at Tempe Downs, yielded nineteen species only; they were:—

Sida corrugata.	Solanum Sturtianum.
Ficus platypoda.	Tecoma australis.
Dodonæa petiolaris.	Postanthera Wilkieana.
Ptilotus incanus.	Eremophila Freelingi.
Acacia aneura.	Callitris robusta.
Thryptomene Maissonneuvii.	Andropogon bombycinus.
Eucalyptus terminalis.	Anthistiria ciliata.
Pomax umbellata.	Aristida calycina.
Aster megalodontus.	Eriachne scleranthoides.

Triodia pungens.

Equally poor results attended the ascents of other elevations. Mount Sonder (4497 feet), the highest elevation explored, yielded rather more species, and the discovery of two noteworthy plants near its summit was the only recompense for an otherwise profitless and toilsome day's work. The same remark will apply to Mount Gillen, and a list of the species observed during the ascent, most of which were living near the summit, at not less than about 1000 feet above the base of its escarpment, here follows:—

Cleome viscosa.	Didiscus Gillenæ.
Abutilon otocarpum.	Grevillea agrifolia.
Hibiscus Pinonianus.	Aster megalodontus.
Dodonæa petiolaris.	Pterocaulon Billardieri.
Ptilotus incanus.	Helichrysum ambiguum.
Ptilotus Hoodii.	Helichrysum Kempei.
Euxolus Mitchelli.	Goodenia Ramelii.
Chenopodium rhadinostacyhum.	Solanum petrophilum.
Boerhaavia diffusa.	Halgania cyanea.
Indigofera brevidens-canescens.	Pollichia Zeylanica.
Cassia eremophila.	Spartothamnus puberulus.
Acacia dictyophleba.	Callitris robusta.
Eucalyptus terminalis.	Macrozamia Macdonnelli.
Eucalyptus gamophylla.	Eriachne scleranthoides.

Triodia pungens.

It may be observed that the inclined slopes and summits of all the elevated masses in the Larapintine region are devoid of soil, the surface presenting the

appearance of a road newly made with large metal, amongst which porcupine-grass grows usually so densely that progress is extremely difficult and even painful if the pedestrian's legs are not well protected; though these impediments may be less discomforting if the tussocks of grass, where not too widely spreading, are availed of by springing from one to another. The faces of these declivities are channelled to varying depths from the condition of mere runnels to deep narrow ravines, which usually terminate in a rock-pool. The majority of the plants occur rooting in the crevices of the rocky walls bounding these water-ways; though it is not an infrequent circumstance to find stately gum trees (*Eucalyptus terminalis*) and pines (*Callitris robusta*) on the scarped fronts of the sandstone table-land.

It is in the gorges of the table-lands and on the basal part of the craggy escarpments and their taluses that a varied flora occurs. These are the habitats of the chief novelties which impart a peculiarity, almost *sui generis*, to the Larapintine flora. With few exceptions the species are endemic; thus of seventy flowering plants, restrictedly rock-dwellers, seven only are of exotic origin, namely, *Capparis spinosa*, *Hybanthus enneaspermus* (but always in the restricted variety *aurantiacus*), *Trema cannabina*, *Parietaria debilis*, *Plumbago Zeylanica*, *Acyranthes aspera*, and *Crotalaria medicaginea*. The richer flora prevails on the southern aspect of the escarpments and on the north walls of the east and west ravines, and it is very probable that some species remain to be discovered in the many unexplored rocky recesses of the George Gill, James, and Krichauff Ranges.

The chief arboreous and shrubby vegetation includes *Hibbertia glaberrima*, *Sida cryphiopetala*, *Ficus platypoda*, *Dodonæa lanceolata*, *D. petiolaris*, *Mirbelia oxyclada*, *Indigofera brevidens*, var. *canescens*, *Erythrina vespertilio*, *Cassia glutinosa*, *C. pruinosa*, *Acacia lycopodifolia*, *A. strongylophylla*, *Eucalyptus terminalis*, *E. pachyphylla*, *Grevillea agrifolia*, *Tecoma australis*, *Prostanthera Wilkieana*, *Eremophila Goodwini*, *Callitris robusta* and *Encephalartos Macdonnelli*.

The chief herbaceous plants are *Oxalis corniculata*, *Parietaria debilis*, *Ptilotus parvifolius*, *P. exaltatus*, *P. Schwartzii*, *Crotalaria medicaginea*, *Aster megalodontus*, *A. Ferresi*, *Helichrysum ambiguum*, *Isotoma petræa*, *Scævola ovalifolia*, *Goodenia Ramelii*, *G. Vilmoriniæ*, *Ruellia primulacea*, *Justicia Kempeana*, *Plectranthus parviflorus*, *Cynoglossum Drummondi*, *Eriachne scleranthoides*, *Triodia pungens*, and *Cheilanthes tenuifolia*.

As already stated, the characteristic vegetation of the Larapintine region is supplied by its saxatile species. Of these only a limited number extend to far-reaching localities, *e.g.*, *Oxalis*, *Parietaria*, *Ptilotus exaltatus*, *P. parvifolius*,

Hydrocotyle trachycarpa, *Isotoma petræa*, *Cynoglossum Drummondi*, *Callitris*, *Cheilanthes tenuifolia*, *C. vellea*, and *Grammitis rutæfolia*.

The majority of the Larapintine species was originally discovered within the region, but in later years this saxatile flora has been known to extend to Mount Olga, the Musgrave, and Everard Ranges in South Australia, and to cross to the Cavenagh Range in West Australia. These elevations must therefore be regarded as botanical outliers of the Larapintine region ; furthermore, the range of others has been extended north and north-west, far beyond the limits of this remarkable physiographic area Thus it has come to pass that a few species only remain as yet restricted to within its boundaries.

3. Origin of the Flora.

In my sketch "On the Influence of Physiographic Changes in the Distribution of Life in Australia" (Austral. Assoc. Adv. Science, vol. i., pp. 312–325, 1889), I have indicated that the flora of Australia consists of the following constituent elements :—

1. An immigrant portion derived from at least two separate sources, (*a*) Oriental and (*b*) Andean.

2. An endemic or Australian portion, which is relatively of higher antiquity.

(*a*). That the Autochthonian constituent, which occupies the south-west corner of West Australia, was dismembered in Cretaceous times.

(*b*). That the Euronotian constituent was superimposed by the Oriental and Andean incursions. The Andean immigration was probably coeval with the last glaciation of Australia, which may have been in late Cretaceous or in Paleocene times, and if so then approximately cotemporaneous with the dismemberment of the primitive Australian flora, and therefore antedated the Oriental immigration, which has virtually not ceased since its advent.

(*c*). That in Post-Pliocene times there originated in Central Australia an Eremian flora developed from Autochthonian and Euronotian elements, and largely modified by Oriental immigrants and the species evolved from them.

In the essay above referred to I have dealt with the botanical characteristics of the Eremian region, and they need not be repeated here, as the main facts

relating to the Larapintine flora are embraced therein. Nevertheless some aspects of the two types of vegetation locally represented may be considered.

The Larapintine flora is composed of :—

I.—Exotic species, chiefly Oriental - -	125
II.—Endemic species of exotic genera - -	219
III.—Endemic species of Australian genera -	270
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In the appended tables, from which the above summary is derived, *Pittosporum*, *Ficus*, *Cassia*, *Santalum*, and *Loranthus* are included among the endemic genera for reasons which are explained at page 131, whilst the alliance with South Africa through *Helipterum*, *Encephalartos*, and others, is disregarded as not affecting the main issues touching the origin of the Larapintine flora, and they are also included among the endemic genera.

The species in categories I. and II. belong, as a whole, to the Eremian type of vegetation, and to these should be added fifty-two in category III., which belong to genera characteristically Eremian though endemic, though it is possible that some of them, particularly the vascular cryptogams and aquatic plants may have formed part of the primitive Australian vegetation. An important factor in the problem of the origin of a flora, here wanting, is the geological evidence of the relative periods of introduction of its alien forms, and it is only our knowledge of the modes of dispersion of plants and the varying rapidity by which unoccupied tracts may be re-peopled that permit us to infer that the vascular cryptogams are the first to appear, then the aquatic and paludinal plants, or on coast-lines some flowering plants by means of water carriage, and lastly the bulk of the terrestial species.

TABLE OF EXOTIC GENERA, AND THE NUMBER OF ENDEMIC AND EXOTIC SPECIES.

Genera.	Endemic Species.	Exotic Species.	Genera.	Endemic Species.	Exotic Species.
Cleome	.	1	Elatine	.	1
Capparis	1	1	Bergia	1	1
Erysimum	1	.	Hypericum	.	1
Capsella	1	.	Polygala	.	1
Lepidium	3	1	Zygophyllum	6	.
Hybanthus	.	1	Tribulus	2	1
Drosera	.	2	Erodium	1	.

Genera.	Endemic Species.	Exotic Species.
Oxalis	.	1
Lavatera	1	.
Malvastrum	.	1
Sida	7	1
Abutilon	6	.
Hibiscus	4	.
Gossypium	2	.
Brachychiton	1	.
Melhania	.	1
Waltheria	.	1
Corchorus	2	.
Triumfetta	1	.
Euphorbia	4	.
Phyllanthus	5	.
Trema	.	1
Parietaria	.	1
Dodonæa (D. viscosa)	.	1
Frankenia	.	1
Plumbago	.	1
Portulaca	1	1
Claytonia	5	.
Spergularia	.	1
Polycarpæa	1	1
Gomphrena	1	.
Alternanthera	1	1
Achyranthes	.	1
Euxolus	1	.
Atriplex	4	.
Chenopodium	4	.
Kochia	8	.
Bassia	9	.
Salicornia	2	.
Salsola	.	1
Aizoon	1	.
Zaleya	.	1
Trianthema	1	1
Mollugo	1	2

Genera.	Endemic Species.	Exotic Species.
Polygonum	.	2
Boerhaavia	.	2
Crotalaria	3	2
Lotus	1	.
Psoralea	3	.
Indigofera	2	4
Tephrosia	2	.
Æschynomene	.	1
Glycine	2	.
Erythrina	1	.
Vigna	1	.
Rhynchosia	.	1
Cassia (C. Sophera)	.	1
Neptunia	1	.
Acacia (A. Farnesiana)	.	1
Tillæa	.	1
Rotala	1	1
Ammannia	.	2
Lythrum	.	1
Myriophyllum	1	.
Ventilago	1	.
Hydrocotyle	1	.
Daucus	.	1
Oldenlandia	2	.
Canthium	1	.
Melothria	.	1
Cucumis	.	1
Aster	3	.
Podocoma	1	.
Pluchea	3	.
Epaltes	.	1
Pterocaulon	1	1
Helichrysum	8	.
Gnaphalium	.	3
Siegesbeckia	.	1
Wedelia	2	.
Bidens	.	1

Genera.	Endemic Species.	Exotic Species.
Glossogyne	.	1
Centipeda	1	1
Senecio	5	.
Wahlenbergia	.	1
Erythræa	.	1
Plantago	1	.
Samolus	.	1
Jasminum	2	.
Carissa	1	.
Cynanchum	1	.
Sarcostemma	1	.
Dæmia	1	.
Marsdenia	1	.
Ipomœa	2	.
Convolvulus	1	.
Breweria	1	.
Evolvulus	.	1
Cuscuta	.	1
Solanum	7	.
Datura	1	.
Nicotiana	1	.
Mimulus	.	1
Stemodia	1	1
Limosella	.	1
Buechnera	1	.
Tecoma	1	.
Ruellia	1	.
Justicia	1	1
Plectranthus	1	.
Teucrium	2	.
Verbena	1	.
Clerodendron	1	.
Cynoglossum	1	.
Pollichia	.	1
Heliotropium	4	3
Josephinia	1	.
Ottelia	1	.

Genera.	Endemic Species.	Exotic Species.
Crinum	1	.
Wurmbsea	1	.
Typha	.	1
Naias	.	1
Potamogeton	1	.
Triglochin	2	.
Commelina	.	1
Juncus	.	1
Eriocaulon	1	.
Cyperus	3	4
Heleocharis	.	2
Fimbristylis	.	4
Scirpus	.	4
Lipocarpha	.	1
Fuirena	.	1
Eriochloa	.	1
Panicum	6	3
Setaria	.	2
Pennisetum	1	.
Perotis	.	1
Tragus	.	1
Andropogon	2	4
Imperata	.	1
Erianthus	1	.
Anthistiria	1	1
Aristida	4	.
Stipa	1	.
Pappophorum	1	.
Sporobolus	2	1
Eriachne	2	.
Danthonia	1	.
Chloris	3	1
Eleusine	1	1
Diplachne	.	2
Triodia	3	.
Eragrostis	6	2
Arundo	.	1

Genera.	Endemic Species.	Exotic Species.	Genera.	Endemic Species.	Exotic Species.
Marsilea	...	1	Aspidium	...	1
Psilotum	...	1	Grammitis	1	1
Adiantum	...	1	Lygodium	...	1
Cheilanthes	...	2			

TABLE OF AUSTRALASIAN GENERA, OR ESSENTIALLY SO, WITH NUMBER OF SPECIES TO EACH.

Genera.	No. of Species.	Genera.	No. of Species.
Hibbertia	1	Isotropis	2
Stenopetalum	3	Mirbelia	1
Pittosporum	1	Burtonia	1
Comesperma	2	Daviesia	1
Eriostemon	1	Gastrolobium	1
Plagianthus	1	Templetonia	1
Commerçonia	3	Ptychosema	1
Hannafordia	1	Swainsonia	7
Seringea	3	Kennedya	1
Macgregoria	1	Cassia	10
Adriana	1	Petalostylis	1
Ficus	2	Acacia (phyllodineæ)	24
Casuarina	1	Loudonia	1
Atalaya	1	Haloragis	3
Heterodendron	1	Calycothrix	1
Diplopeltis	1	Thryptomene	2
Dodonæa	3	Bæckea	1
Stackhousia	3	Melaleuca	3
Ptilotus	11	Eucalyptus	10
Rhagodia	2	Cryptandra	1
Dysphania	2	Didiscus	2
Enchylæna	1	Actinotus	1
Babbagia	1	Exocarpos	1
Muehlenbeckia	1	Anthobolus	1
Gryostemon	1	Santalum	2
Codonocarpus	1	Loranthus	5
Pimelea	2	Grevillea	9
Brachysema	1	Hakea	4

Genera.	No. of Species.	Genera.	No. of Species.
Pomax	1	Velleya	1
Brachycome	1	Polymeria	2
Minuria	2	Duboisia	1
Calotis	10	Prostanthera	4
Vittadinia	2	Spartothamnus	2
Pterigeron	3	Newcastlia	2
Ixiolæna	1	Dicrastylis	5
Podolepis	2	Eremophila	17
Waitzia	1	Myoporum	1
Helipterum	10	Halgania	2
Rutidosis	1	Styphelia	1
Millotia	1	Elacholoma	1
Myriocephalus	1	Callitris	1
Angianthus	1	Macrozamia	1
Gnephosis	1	Thysanotus	1
Eriochlamys	1	Corynotheca	1
Calocephalus	1	Xerotes	2
Erechtites	2	Xanthorrhœa	1
Isotoma	1	Livistona	1
Candollea	1	Centrolepis	1
Bruonia	1	Spinifex	1
Leschenaultia	1	Neurachne	1
Catosperma	1	Triraphis	2
Scævola	4	Astrebla	1
Goodenia	15		

The more modern facies of the Eremian flora is shown not only by the high percentage of exotic species (twenty in the Larapintine flora; whilst for the whole Eremian flora in South Australia I have stated it to be, writing in 1888,* 16·8, thus indicating an increase in the northern area, as might be expected as we approach their centres of dispersal), but also by the wide dispersal of a large number of them, which thus evince a quality of accommodating themselves to a great variety of climatic and other physical influences.

The majority of the plants possessing burr-like, pungent, pointed or adhesive fruits belong either to exotic species or to endemic species of exotic genera, and

* Austr. Assoc. Adv. Science, vol. i., p. 317.

are widely dispersed over the low-level tracts, though some ascend to high elevations on the rocky country. The rare instances of species with such aids for dispersal, which are local and saxatile, are *Achyranthes aspersa* and *Plumbago Zeylanica.* The only species of endemic genera whose fruits possess clinging appendages, which would aid their transport by the agency of animals, belong to *Calotis*, all of which inhabit the lowland areas. The feathery achenes of some Compositæ, except perhaps in *Senecio*, are not sufficiently buoyant to be useful aids in their distribution unless under the influence of very high winds, which were not at all experienced during our stay. The same remark applies to the winged fruits of *Atalaya*, etc., to the coma-bearing seeds of the Asclepiads, Hibiscus, etc., and to the winged seeds of *Casuarina*, *Tecoma*, etc.

The number of species bearing edible fruits is absolutely few. They belong for the most part to species of endemic genera, and, with the exception of *Anthobolus* and *Styphelia*, which are saxatile and very rare, are widely diffused over the low levels. In *Melothria* and *Cucumis* we have two exotic forms widely diffused, and in *Trema*, another exotic, saxatile and rare. We know too little of the natural foods of the native birds to make them accountable for the diffusion of plant species, the seeds or fruits of which they may live on. The emu, which is actually known to be an agent in the dispersal of *Santalum*, may also play the same *rôle* in regard to other species yielding pulpy fruits. The parrots and pigeons during the time of our sojourn were feeding on graminaceous seeds. The little *Dicaeum hirundinaceum* lives chiefly on the berries of *Loranthus spp.*, and in consequence the distribution of the bird is coterminous with that of its food-plants. Tasmania and Kangaroo Island, where the bird is absent, do not possess a single species of *Loranthus.* Thus, though among the lowland vegetation there are many species possessing advantages for their dispersal, yet among the saxatile vegetation such properties are almost wholly wanting. The details are set forth in the following table :—

	Genera Exotic. Sp. Exotic.	Genera Exotic. Sp. Endemic.	Genera Endemic.	Distribution.
(*a*) *Burr-like Fruits—*				
Triumfetta micracantha	-	x	-	Very rare.
Tribulus terrestris	x	-	-	Lowland, wide-spread.
Achyranthes aspera	x	-	-	Saxatile, local.
Bassia, spp.	-	x	-	Lowland, several wide spread.
Salsola kali	x	-	-	Lowland, wide-spread.
Daucus brachiatus	x	-	-	Lowland, wide-spread.
Glossogyne tenuifolia	x	-	-	Lowland, common.

	Genera Exotic. Sp. Exotic.	Genera Exotic. Sp. Endemic.	Genera Endemic.	Distribution.
Bidens tripartita	x			Lowland, rare.
Calotis, spp.			x	Lowland, mostly wide-spread.
Cynoglossum Drummondi		x		Saxatile, common.
Andropogon Gryllus	x			Lowland, not rare.
Anthistiria ciliata	x			Lowland, wide-spread, also saxatile.
Anthistiria avenacea		x		Lowland, wide-spread.
Tragus racemosus	x			Lowland, exceedingly diffused.
Aristida, spp.		x		Lowland, wide-spread, and partly saxatile.
Chloris acicularis		x		Lowland, common.
Stipa scabra		x		Lowland, rare.

(*b*) *Adhesive Fruits*—

	Genera Exotic. Sp. Exotic.	Genera Exotic. Sp. Endemic.	Genera Endemic.	Distribution.
Cleome viscosa	x			Lowland and saxatile, wide-spread.
Boerhaavia diffusa	x			Lowland and saxatile, wide-spread.
Boerhaavia repanda	x			
Plumbago Zeylanica	x			Saxatile, local.
Siegesbeckia orientalis	x			Lowland, wide-spread.

(*c*) *Fleshy Fruits*—

	Genera Exotic. Sp. Exotic.	Genera Exotic. Sp. Endemic.	Genera Endemic.	Distribution.
Rhagodia spinescens			x	Lowland, common.
Rhagodia nutans			x	Lowland, common.
Enchlyæna tomentosa			x	Lowland, common.
Trema cannabina	x			Saxatile, rare.
Anthobolus exocarpoides			x	Saxatile, very rare.
Santalum, spp.			x	Lowland, common.
Melothria maderaspatana	x			Lowland, common.
Cucumis chate	x			Lowland, not uncommon.
Loranthus, spp.			x	Lowland, common.
Myoporum Dampieri			x	Lowland, common.
Scævola spinescens			x	Lowland, common.
Jasminum, spp.		x		Lowland.
Clerodendron floribundum			x	Lowland, not uncommon.

	Genera Exotic. Sp. Exotic.	Genera Exotic. Sp. Endemic.	Genera Endemic.	Distribution.
Spartothamnus teucriifolius	-	-	x	Lowland, not uncommon.
Spartothamnus puberulus -	-	-	x	Saxatile, very rare.
Carissa Browni - -	-	x	-	Lowland and saxatile.
Solanum, spp. - - -	-	x	-	Lowland, wholly or in part.
Styphelia Mitchelli - -	-	-	x	Saxatile, very rare.

The colonising power possessed by the Eremian plants has had freer scope to exercise itself in the unoccupied tract of the low levels on the reduction in size of its lake-basins and water-ways than was possible in the more stable external regions. Another feature pointing in the same direction is the high state of specific luxuriance in many of its exotic genera; and that a process of differentiation seems to be in progress, because of the local racial characters exhibited in some genera and species. Further, the many monotypic genera, which are for the most part offsets from Australian types altered by new surroundings, show no singularity which may be attributed to a high antiquity.

An indispensable property of the Eremian plants is that of rapid germination, so as to take advantage of the rare opportunities when the physical and hygrometric conditions of the soil are favourable and quite irrespective of temperature. Moreover, the long droughts intervening between the favourable periods necessitate another quality in their seeds—that of resistance to long exposure. Individual tenacity of life is another essential condition of maintaining a foothold in the dry or desert zone.

The balance of 218 species in category III. are either actually Autochthonian or Euronotian, or are related species, and as a whole may be viewed either as residues of a common Australian flora, or as modified descendants therefrom. Here belong all the saxatile species of endemic genera, as also others of endemic genera inhabiting the low-level tracts.

The Larapintine area, in common with the rest of Australia, contains representative genera of that primitive flora which marks the close of the Cretaceous and the early stages of the Tertiary period, as has been made known chiefly by the researches of Baron von Ettinghausen (Contributions Tertiary Flora of Australia, Mem. Geol. Surv., N.S.W., 1888). The forms belonging to this type of vegetation, which are present in the area, are *Ficus*, *Loranthus*, *Pittosporum*, *Santalum* and *Cassia*, in association with *Callitris*, *Casuarina*, *Grevillea*, *Hakea*, *Eucalyptus*, and phyllodineous *Acaciæ*, now restricted to Australia. Most of the

first series, when viewed by their present geographic distribution, are considered Oriental; but in regard to their distribution, in time they belong to a Cosmopolitan flora, which originated in Late Cretaceous times in Europe, North America, and Australia; hence their modern representatives, except the exotic species, may actually be descendants of primitive Australian species, and not modified immigrant forms.

The isolation of many of the Larapintine species and the sporadic occurrences of others are facts suggestive of the opinion that they are modified descendants of a primitive flora. Thus the fan-palm, *Livistona Mariæ*, is known by one colony only, estimated to comprise not more than a hundred mature individuals, and though seedlings are numerous, yet very few juvenescent examples were observed; also on the banks of the Finke River, below its junction with Palm Creek, considerable numbers of young plants were seen, whilst the number of full-grown trees does not exceed a dozen. It may therefore be inferred from these circumstances that a powerful agency is at work repressing the increase of individuals and endangering the very existence of the species. The grass-tree, *Xanthorrhœa Thorntoni*, is restricted to a belt of sandy country of about seventy miles long and thirty miles wide. *Brachysema Chambersii* is gregarious, though usually the colonies are extensive. *Xerotes dura* is known in two colonies of a very limited number of individuals, some fifty miles apart. *Swainsonia canescens* occurs in two colonies, occupying a few square yards, seventy-seven miles apart. *Gastrolobium grandiflorum* is very local and the colonies widely separated. *Goodenia Horniana* occurs in two colonies of few individuals, separated by 100 miles. *Bæckea polystemonea* is restricted to two localities, 260 miles apart. Whilst *Actinotus Schwartzii*, *Didiscus Gillenæ*, *Prostanthera Schultzii*, *Styphelia Mitchelli* and a few others are restricted, so far as known, each to a circumscribed habitat. Moreover, some of the endemic species of exotic genera, and even some immigrant species, occur in small single colonies. Of the former may be mentioned *Grammitis Reynoldsi* and *Ottelia ovalifolia*, and of the latter *Heleocharis capitata*, *Lipocarpha microcephala*, *Psilotum triquetrum*, *Adiantum hispidulum*, and *Aspidium unitum*. As the majority of these exemplar species are so conspicuous, or of others because of the particularity of their habits, there cannot be room to doubt the general applicability of the opinion which I have formed as to their sparse distribution. And though a suspicion may be raised that they are stragglers from outlying regions, yet our knowledge of their extra-limital distribution forbids such an explanation. Thus for the majority of the species the Larapintine region is their metropolis, whilst others which range beyond it are equally sporadic in their occurrences. In the latter category the following selected species may serve as illustrations:—

Sida inclusa, N.A., Hammersley Range; *Sida lepida*, N.W.A., De Grey River, Gascoyne River; *Claytonia spergularina*, Nicholson River, Gulf of Carpentaria and Cape's River, Queensland. *Ptilotus parvifolius* extends to the southern confines of the Central Eremian region and crosses into New South Wales, but is rare in these external areas; *Brachysema Chambersii* is known also from Barrow Range and in N.A.; *Mirbelia oxyclada*, Victoria River, Arnheim Land, Hammersley Range; *Burtonia polyzyga*, the only external locality is Mount Morphett on the confines of Burt Plain; *Swainsonia canescens* is known at two other localities, Swan River and Nickol Bay; *Cassia glutinosa* at Attack Creek; *Grevillea eriostachya*, Murchison River, Champion Bay, Nickol River; *Catosperma Muelleri*, Victoria River and River Thomson in Queensland.

From the known habits of the exotic species inhabiting the rocks and pools of the Larapintine gorges and ravines, it may be inferred from the circumstance of their local occurrence that they, as well as the Australian species previously quoted, are on the verge of extinction within the Larapintine area. It is satisfactorily established, on geological and biological data, that from Pliocene times the rainfall in Central Australia has greatly diminished; so that, if species of plants were introduced to the region during the duration of the favourable climatic conditions, it is not unreasonable to suppose that those less adapted to increasing desiccation would disappear, or continue to live only in those restricted areas where the struggle for existence would be the least severe. Hence, the deep-shaded gorges and escarpments, particularly those with perennial water-flows (the rock-structures in the George Gill and Krichauff Ranges are especially favourable), have become harbours of refuge to the few survivors of an extinct population.

The most ancient species among the living generation of Australian plant, is *Callitris robusta*, which inhabited Central Australia coeval with the large extinct marsupalia, as they are associated in the Pliocene clays at Lake Callabonna.* However, the species is absent in a living state from the Central Eremian regions and does not appear in a northerly direction till the Larapintine table-land is reached.

The minor influences checking reproduction of the species of the endemic flora as consequences of increased aridity are:-

(1) The general absence of perennial streams and the salinity of the surface stores of water, which increases with the prolongation of the rainless season.

* Tate, Trans. Roy. Soc. S. Aust., vol. xviii., p. 195, 1894.

Thus Palm Creek, at the time of our visit, contained a slight flow of fresh water, whilst the waterholes in the channel of the River Finke, in the Glen of Palms, was undrinkable; the latter circumstance may explain the rare occurrence of the fan-palm in the Glen of Palms, though it is in near proximity to the main colony at the former place.

(2) Frost. The main flowering period follows on that of the chief precipitation of rain, which usually takes place in January or February; so that, by the time the arboreous and shrubby vegetation has regained its vigour and the flowering condition reached, the season of nightly frosts has been entered upon.* However, before this has come to pass the annual vegetation has for the most part run its course. Though the effects of frost were not general, yet in the case of the following species (*Cassia venusta*, *Santalum acuminatum*, *Clerodendron floribundum*), growing in open places they were most marked, not only the flowering buds killed, but the foliage presented a withered appearance. To the same cause I attribute the not infrequent absence of mature seeds, either by checking the perfection of the sexual organs or by killing-off those insects (and certainly at the time of our visit insect life was feebly represented) which are the agents of pollinisation.

Some of the Larapintine plants may be regarded as connecting links between the Autochthonian and Euronotian floras, and in some species to indicate the horizontal plane of divergence from the primitive stock. Among restricted species *Xanthorrhœa Thorntoni*, though occupying an insular position, is the centre of a semi-circumferential distribution of the genus, from the south-west by south to east and north-east of the continent. The same remark is applicable to *Commerconia*, spp., *Anthobolus exocarpoides*, *Bæckea polystemonea*, *Actinotus Schwarzii* and *Macrozamia Macdonnelli*.

Hibbertia glaberrima stands alone as an extralimital species in the section Hemihibbertia, otherwise Autochthonian. It ranges from Queensland through the Larapintine area (its metropolis) to Mount Olga and Everard Range. *Gastrolobium grandiflorum* is the only extra-Autochthonian species of this large genus, and radiates from the Larapintine region to Attack Creek and Newcastle Waters on the north, to the adjacent parts of Queensland and New South Wales, and to the Eremian portion of West Australia. *Brachysema Chambersii* is a link between the home of the genus in West Australia and the northern stations of a

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* The minimum thermometric readings were almost always below freezing point, and the greatest cold registered was 15 deg. F.

few species ; in a south-west direction this species extends to Barrow Range. The same remarks apply equally well to *Mirbelia oxyclada*, *Burtonia polyzyga*, *Isotropis*, spp., *Leschenaultia divaricata* and *Styphelia Mitchelli.* In this connection the genus *Jacksonia* is conspicuously absent from the Larapintine basin.

Conclusions.—The distribution of the constituent elements of the Larapintine flora and their exoteric relationships, taken in conjunction with the physiographic changes that have taken place within the area, lead to the conclusions that :—

1. The Larapintine table-land was isolated, except perhaps in a northerly direction, during the deposition of the marine sediments constituting the Rolling Downs system (Upper Cretaceous).

2. The marine submergence was replaced by a lacustrine area during the deposition of the Desert Sandstone (Supra Cretaceous).

3. A cosmopolitan flora prevailed at this period, which continued into Paleocene times.

4. The area occupied by the lacustrine area of the Desert Sandstone period was somewhat reduced, yet high pluvial conditions continued into Pliocene times.

5. In Post-Pliocene times a high state of desiccation was reached, which has continued till to-day. The cosmopolitan flora became largely extinct, and its place occupied by an Oriental immigration, more especially over the previously-submerged areas.

4. Previous Explorations.

The first botanical exploration of the Larapintine region was by J. Macdouall Stuart, who collected during his traverses from the Finke River to the McDonnell Range in 1860-62. The plants were determined by Baron von Mueller, and their enumeration published as an appendix to the "Journals of J. McD. Stuart," London, 1864. Of the fifty-two species catalogued, thirty-two were gathered within the area which forms the subject of this report ; seven of them were scientifically unknown till described by F. von Mueller in vols. ii. and iii. of the "Fragmenta Phyt. Aust."

Ten years later Ernest Giles geographically explored the Larapintine region to the westward of the Finke River, and made extensive botanical collections. A list of the species, furnished by Baron von Mueller, was published as an appendix to Mr. E. Giles' "Geographic Travels in Central Australia," 1872-74 (Melbourne,

1875). It contains the names of 254 species, of which 114 belong to the Larapintine flora, but as seventeen had already been recorded from Stuart's material, the actual gain in numbers is reduced to ninety-seven, making a total known at this time to be 129.

Cotemporaneously with Giles, W. C. GOSSE crossed the western confines of the Larapintine region in his traverse from Central Mount Wedge and Mount Liebig to Mount Olga, and though he collected plants during his explorations, yet the only record as regards this particular region is that of "grass trees" (*sic*) in the neighbourhood of Glen Edith.

The Rev. H. KEMPE, of the Mission Station at Hermannsburg, made successive collections of plants in his neighbourhood, which were determined by Baron von Mueller, and their names were communicated in two lists to the Royal Society of South Australia, and published in its Transactions, vol. iii., p. 129, 1880, and vol. v., p. 19, 1882. The result of Mr. Kempe's investigations, as far as numbers are concerned, is, at the latter date, 287 species, and of these 219 are records of additional species, making the total known for the region 348.

In 1889 Mr. TIETKENS traversed the northern part of the Larapintine region, from Alice Springs to its western limit, and added fifty-eight species, including five new to science, to the Larapintine flora. A list of the plants collected by him is published in the Trans. Roy. Soc. S. Aust., vol. xiii., pp. 94–109, 170–171, 1890.

Lastly, from collections received by Baron von Mueller, during the period intermediate between the two last-named, from the missionaries at Hermannsburg, the officers attached to the Telegraph Stations at Charlotte Waters and Alice Springs, and from other residents within the region, he has from time to time published diagnoses of new species and records of others previously unknown in this region.

From these various sources of information I have compiled the accompanying List of Plants, adding my records of localities of those plants actually observed in life. Since the return of the Expedition Mr. F. J. Gillen, of Alice Springs, has forwarded a collection of flowering plants gathered in his immediate neighbourhood; from it I am able to insert "Alice Springs" as an additional locality for several species.

The number of species known previous to the advent of the Horn Expedition was 502, which is now increased to 614. The additions are comprised of: new

species, 8; new for South Australia, 16: new for the region, 112. *Threlkeldia proceriflora*, gathered at Adminga, in the Central Eremian region, is another addition to the provincial flora.

To Baron von Mueller I am indebted for assistance in the determination of a few critical species, as well as for certain notes which are incorporated in the following enumeration of plants, and the authorship of which is in each case indicated.

5. Enumeration of the Plants of the Larapintine Region.

[Index to signs:—* saxatile species, ‖ exotic species, ! signifies that the species was observed at the station indicated.]

DILLENIACEÆ.

* Hibbertia glaberrima, *F. v. M.* Restricted to rocky ravines; Glen of Palms (E. Giles) and its tributary Palm Creek! in Krichauff Range; Reedy and Bagot's Creeks! in George Gill Range; Redbank Gorge by Mount Sonder! and Brinkley Bluff! (Stuart) in McDonnell Range. Extends south-west to Mount Olga (Tietkens) and Everard Range (Elder Exped.).

CAPPARIDEÆ.

‖ Cleome viscosa, *Linné.* Extends from Macumba River to McDonnell Range, as at Glen Helen!; chiefly in the alluvial valleys and by creek margins, but ascends the rocky declivities to high altitudes, as near the summit of Mount Gillen!

*‖ Capparis spinosa, *Linné.* A lax shrub, attaining to eight to twelve feet high, growing in the shade of fig trees; confined to rocky ground and ascending to considerable altitudes above the river plains. Ilpilla Gorge!; Illara Water!; Palm Creek! in Krichauff Range (Kempe); Gill's Pass!; Alice Springs!; near Mount Sonder (Tietkens).

Capparis Mitchelli, *Lindley.* A small tree, widely dispersed, but never gregarious, chiefly on loamy ground, becoming shrubby on rocky ground. Henbury!; Ilpilla!; Tempe Downs!; south side of George Gill Range!; source of Carmichael Creek!; Upper Finke and tributaries near Mount Sonder!, etc.; McDonnell Range and Mount Udor (E. Giles); Hermannsburg (Kempe); Dashwood Creek (Tietkens).

CRUCIFERÆ.

Erysimum lasiocarpum, *F. v. M.* On loamy flats; Henbury!; junction of Finke and Palmer Rivers; River Hugh at Alice Well!; Alice Springs!.

Stenopetalum velutinum, *F. v. M.* Laurie's Creek!; slopes of Mount Francis, Belt Range!; Hermannsburg (Kempe).

Stenopetalum lineare, *R. Br.* Hermannsburg (Kempe).

Stenopetalum nutans, *F. v. M.* Alluvial flats and loamy plains. Ilpilla!; Glen Helen!; Horn Valley!*; Burt Plain!; Bond Spring (Tietkens); Hermannsburg (Kempe).

Capsella ochrantha, *F. v. M.* Mount Sonder (Tietkens).

Lepidium rotundum, *De Cand.* Loamy flats in Horn Valley!; near Hermannsburg (Kempe).

Lepidium phlebopetalum, *F. v. M.* Alice Springs! (C. Giles); Glen Helen! (Tietkens); Stuart's Pass!; Ooraminna Pass and Waterhouse Range!; Hermannsburg (Kempe).

Lepidium papillosum, *F. v. M.* Common throughout the region, chiefly on loamy plains, as at Hermannsburg (Kempe); also on the escarpment of George Gill Range!.

|| Lepidium ruderale, *Linné.* Common in most places by creeks, Henbury, &c.!; Hermannsburg (Kempe).

VIOLACEÆ.

*|| Hybanthus enneaspermus, *F. v. M.* Slopes of Mount Tate!; Alice Springs!; McDonnell Range (E. Giles); near Hermannsburg (Kempe); Gill's Creek (Tietkens).

PITTOSPOREÆ.

Pittosporum phillyroides, *De Cand.* Sparsely dispersed throughout the region. Sullivan Creek!, Illara Water!, south side of George Gill Range, Burt Plain!, etc.; Gosse's Range (E. Giles); Hermannsburg (Kempe).

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* This station refers to that part of the valley between Goyder Pass and Finke Gorge.

DROSERACEÆ.

| DROSERA INDICA, *Linné.* Marshy ground at Reedy Creek ! ; Stuart's Pass ! ; Conlin's Lagoon near Heavitree Gap ! ; Glen Farewell and Laura Vale (Tietkens) ; Finke River (Stuart) ; also, wet banks of the River Stevenson !.

| DROSERA BURMANNI, *Vahl.* McDonnell Range (E. Giles) ; Glen Farewell and Laura Vale (Tietkens).

ELATINEÆ.

ELATINE AMERICANA, *Arnott.* Marshy ground in Stuart's Pass, near Brinkley Bluff !, and in gorge of Bagot's Creek in George Gill Range !.

| BERGIA AMMANNIODES, *Roxburgh.* Margin of Conlin's Lagoon, near Emily Gap ; Darwent Creek ! ; Carmichael Creek ! ; also River Stevenson !.

BERGIA PERENNIS, *F. v. M.* Hermannsburg (Kempe), near Mount Sonder (Tietkens).

HYPERICINÆ.

| HYPERICUM JAPONICUM, *Thunberg.* Margin of Gully Waterhole near Tempe Downs ! ; Reedy Creek ! ; Stuart's Pass ! ; Mount Sonder and west of McDonnell Range (Tietkens).

POLYGALEÆ.

‖ POLYGALA CHINENSIS, *Linné.* Alice Springs (C. Giles).

COMESPERMA SYLVESTRE, *Lindley.* Between McDonnell and Gill Range (E. Giles).

COMESPERMA VISCIDULUM, *F. v. M.* McDonnell Range (E. Giles).

RUTACEÆ.

* ERIOSTEMON ARGYREUS, *F. v. M.* and *Tate.* Near Mount Sonder (Tietkens).

ZYGOPHYLLEÆ.

ZYGOPHYLLUM APICULATUM, *F. v. M.* Illamurta Soakage, in James Range ! ; mallee scrub by banks of Upper Finke, under Mount Sonder ! ; Hermannsburg (Kempe).

Zygophyllum iodocarpum, *F. v. M.* Stony ground, east end of George Gill Range, and by Upper Finke near Mount Sonder ! ; Alice Springs (C. Giles).

Zygophyllum prismatothecum, *F. v. M.* River Finke at Idracowra ! ; limestone slopes of Mount Sonder !.

Zygophyllum ammophilum, *F. v. M.* River Finke at Crown Point, Henbury and Idracowra ! ; sources of Rudall's and Darwent Creeks ! ; Finke Gorge and Horn Valley ! ; Ooraminna Pass ! ; banks of the River Hugh at Alice Creek ! ; Alice Springs (C. Giles) ; Hermannsburg (Kempe).

Zygophyllum fruticulosum, *De Cand.* Mount Harris (Tietkens) ; Hermannsburg (Kempe).

Zygophyllum Howittii, *F. v. M.* River Finke at Engoordina and Crown Point ! ; also Lilla Creek at Mount Humphries !, the most northern stations of the species.

|| Tribulus terrestris, *Linné.* Common on loamy and sandy soils throughout the region !. Recorded by Kempe.

Tribulus macrocarpus, *F. v. M.* Plain at foot of Belt Range ! ; also sandhills from Mount Squire to the Goyder River !, near Charlotte Waters (Kempe).

Tribulus astrocarpus, *F. v. M.* No locality (Tietkens).

GERANIACEÆ.

Erodium cygnorum, *Nees.* Rich loamy plains ; south side of George Gill Range ! ; Vale of Tempe ! ; Horn Valley !, and Conlin's Lagoon ! ; Hermannsburg (Kempe).

|| Oxalis corniculata, *Linné.* Damp shady rocks and creek banks ; Reedy Creek Gorge ! ; gorge of the Darwent ! ; deep ravine of Mount Tate !, by Mount Sonder ! (Tietkens) ; Stuart's Pass !, Alice Springs (F. J. Gillen !).

Macgregoria racemosa, *F. v. M.* McDonnell Range (E. Giles) ; Lake Macdonald (Tietkens). Extends to Ryan's Well, ninety miles north of Alice Springs (F. J. Gillen !)

MALVACEÆ.

Lavatera plebeia, *Sims.* Banks of the River Finke in Finke Gorge ! ; Hermannsburg (Kempe).

† MALVASTRUM SPICATUM, *A. Gray.* Widely spread from Oodnadatta to Burt Plain !, Hermannsburg (Kempe).

PLAGIANTHUS GLOMERATUS, *Bentham.* Lake Macdonald (Tietkens); near Hermannsburg (Kempe).

SIDA CORRUGATA, *Lindley.* Widely spread. Sullivan's Creek !, about Tempe Downs !, valley of Carmichael Creek !, slopes of Mount Tate !. Gosse and McDonnell Ranges (E. Giles); Hermannsburg (Kempe).

SIDA VIRGATA, *Hooker.* Sand-plain between Glen Edith and Carmichael Creek !, slopes of Mount Tate !, Hermannsburg (Kempe).

* SIDA CRYPHIOPETALA, *F. v. M.* A lax erect shrub up to six feet high, growing on rock-slopes and ravines at Glen Helen and Finke Gorge, Palm Creek, Palmer River, Reedy Creek, Darwent River, Stuart's Pass !; Brinkley Bluff (Stuart) and McDonnell Range (E. Giles); Alice Springs (F. J. Gillen !).

* SIDA PETROPHILA, *F. v. M.* McDonnell Range (E. Giles).

† SIDA RHOMBIFOLIA, *Linné.* Hermannsburg (Kempe).

SIDA INCLUSA, *Bentham.* Sandy loam flats, Ilpilla, Bagot's Creek, Carmichael Creek, and Ooraminna Pass !; McDonnell Range (E. Giles); Warman Rocks and Engoordina (Tietkens).

SIDA LEPIDA, *F. v. M.* Hermannsburg (Kempe).

SIDA PODOPETALA, *F. v. M.* and *Tate.* Ilpilla Gorge in James Range !; Penny's Creek in George Gill Range !; Glen Helen and Warman Rocks (Tietkens); Alice Springs (F. J. Gillen !).

* ABUTILON TUBULOSUM, *Hooker.* Ranges near Hermannsburg (Kempe); Sullivan's Creek, Tempe Downs, Redbank Creek, Stuart's Pass, and Mount Gillen !; Glen Helen and Laura Vale (Tietkens). Wide spread, Hermannsburg (Kempe).

ABUTILON CRYPTOPETALUM, *F. v. M.* Wide spread, Hermannsburg (Kempe). Stuart's Pass !.

ABUTILON OXYCARPUM, *F. v. M.*; VAR. with the sepals as long as the fruitlets. Bed of the Finke between Henbury and Parkes Gap !; Ilpilla Gorge !; Bagot's Creek ! and Stuart's Pass !.

ABUTILON FRASERI, *Hooker.* Idracowra, east end of George Gill Range and Horn Valley !. Widely spread, Hermannsburg (Kempe).

ABUTILON HALOPHILUM, *F. v. M.* Glen Helen and Laura Vale (Tietkens).

ABUTILON MACRUM, *F. v. M.* Glen Helen !.

HIBISCUS MICROCHLÆNUS, *F. v. M.* Bond Springs, near Mount Sonder !, and Laura Vale (Tietkens) ; Hermannsburg (Kempe).

HIBISCUS PINONIANUS, *Gaud.* Lake Macdonald (Tietkens). VAR. with leaves shortly lobed ; Ipilla Gorge, slopes of Mount Tate, Darwent River Gorge and Mount Gillen !.

HIBISCUS FARRAGEI, *F. v. M.* McDonnell Range (E. Giles) ; Upper Finke and tributaries by Mount Sonder ! ; near Hermannsburg (Kempe) ; banks of the Palmer River at Illara Water !.

* HIBISCUS STURTII, *Hooker.* Stuart's Pass ! ; slopes of Mount Tate ! ; rocks near Hermannsburg (Kempe). VAR. with broadly oval leaves, Belt Range !.

GOSSYPIUM STURTII, *F. v. M.* Gosse's and McDonnell Ranges (E. Giles) ; Mount Sonder ! ; Ooraminna Pass ! (Tietkens) ; Hermannsburg (Kempe) ; Mereenie Bluff and Tempe Downs !.

GOSSYPIUM AUSTRALE, *F. v. M.* Glen Helen and Laura Vale (Tietkens) ; Belt Range, Horn Valley, and east end of George Gill Range ! ; near Hermannsburg (Kempe).

STERCULIACEÆ.

BRACHYCHITON GREGORII, *F. v. M.* McDonnell Range, Mount Udor, and Carmichael Creek (E. Giles). Sandhills between source of Laurie's Creek and Glen Edith, between Glen Edith and Carmichael Creek, Missionary Plain, south-west of Gosse Range, and between Ooraminna and James Range !.

| MELHANIA INCANA, *Heyne.* East end of George Gill Range ! ; Hermannsburg (Kempe).

‖ WALTHERIA INDICA, *Linné.* Redbank Creek by Mount Sonder ! ; banks and channel of River Hugh in Stuart's Pass ! ; Glen of Palms (Kempe).

COMMERÇONIA KEMPEANA, *F. v. M.* Sandhills between Glen Edith and Carmichael Creek ! ; Watson Hills (Tietkens) ; near Hermannsburg (Kempe). Extends to the Victoria Desert (Elder Exped.).

COMMERÇONIA LOXOPHYLLA, *F. v. M.* McDonnell Range (E. Giles).

* COMMERÇONIA MAGNIFLORA, *F. v. M.* Mount Sonder (Tietkens). Ranges near Hermannsburg (Kempe); Glen of Palms (E. Giles). Rocky ravines of the River Palmer and of the George Gill Range!. Extends to Mount Olga (E. Giles) and Everard Range (Elder Exped.).

HANNAFORDIA BISSILLII, *F. v. M.* Sand plain by the River Finke at Running Water!; between Glen Edith (Tietkens) and Carmichael Creek!; ranges near Hermannsburg (Kempe).

SERINGEA COROLLATA, *Steetz.* McDonnell Range (E. Giles).

SERINGEA NEPHROSPERMA, *F. v. M.* McDonnell Range (E. Giles).

SERINGEA INTEGRIFOLIA, *F. v. M.* Sand plain at Engoordina and at Running Water!; McDonnell Range (E. Giles).

TILIACEÆ.

CORCHORUS ELDERI, *F. v. M.* North of McDonnell Range (Dittrich).

CORCHORUS SIDOIDES, *F. v. M.* McDonnell Range (Stuart); Hermannsburg (Kempe).

TRIUMFETTA MICRACANTHA, *F. v. M.* South-westward of the Finke River (Schwarz); (F. v. M. in litteris, 10–9–1891).

EUPHORBIACEÆ.

EUPHORBIA MITCHELLIANA, *Boissier.* Sandy margin of River Walker at Tempe Downs!.

EUPHORBIA ERYTHRANTHA, *F. v. M.* By Mereenie Bluff, east end of George Gill's Range, Belt Range!. Lake Macdonald (Tietkens).

EUPHORBIA DRUMMONDII, *Boissier.* Hermannsburg (Kempe); Mount Tate!; Tempe Downs!. Mount Ziel (Tietkens).

EUPHORBIA EREMOPHILA, *Cunningham.* Belt Range and Mount Sonder!; McDonnell Range (E. Giles); Emily Gap (Tietkens); Hermannsburg (Kempe).

PHYLLANTHUS THESIOIDES, *Bentham.* Burt Plain (Tietkens); near Finke River and Charlotte Waters (Kempe).

PHYLLANTHUS RHYTIDOSPERMUS, *F. v. M.* Conlin's Lagoon by Emily Gap!, also River Finke at Crown Point!; Hermannsburg (Kempe); Glen Helen, as *P. minutiflorus* (Tietkens).

PHYLLANTHUS FUERNROHRII, *F. v. M.* Sandhills by the Finke River at Engoordina and Idracowra !, by Bagot's Creek, and by the Hugh at Alice Well !. *Var.*—Hoary, leaves larger and somewhat distichous ; limestone surface in Ooraminna Pass !.

PHYLLANTHUS LACUNARIUS, *F. v. M.* McDonnell Range (Tietkens) ; loam banks of Darwent River !.

PHYLLANTHUS TRACHYSPERMUS, *F. v. M.* Mount Sonder (Tietkens).

ADRIANA TOMENTOSA, *Gaud.* McDonnell Range (E. Giles) ; Hermannsburg (Kempe) ; Tempe Downs and north to Mount Sonder ! ; also Crown Point.

URTICACEÆ.

*|| TREMA CANNABINA, *Loureiro.* Redbank Gorge !, near Mount Sonder (Tietkens) ; Stuart's Pass ! ; Alice Springs (F. J. Gillen !).

* FICUS PLATYPODA, *Cunningham.* On all extensive rocky outcrops throughout the Larapintine region !. Recorded by Stuart, E. Giles, Kempe and Tietkens.

* FICUS ORBICULARIS, *Cunningham.* Glen of Palms (E. Giles).

*|| PARIETARIA DEBILIS, *G. Foster.* Shaded rocks, Finke Gorge ! ; Palm Creek ! ; ranges near Hermannsburg (Kempe).

CASUARINEÆ.

CASUARINA DECAISNEANA, *F. v. M.* On sandhills throughout the Larapintine region, reaching its southern limit a few miles north of Engoordina !; between Ayers Rock and Mount Olga (Spencer), and between the Lilla Creek and Erldunda (Tietkens). Recorded by Stuart, E. Giles, Kempe and Tietkens.

SAPINDACEÆ.

ATALAYA HEMIGLAUCA, *F. v. M.* McDonnell Range (E. Giles) ; Hermannsburg (Kempe) ; loam flats, Burt Plain !, Upper Finke by Mount Sonder !, south side of George Gill Range !, Henbury !, and Chandler's Range. Also at base of Johnston's Range, Engoordina and Mount Squire, Crown Point to the Goyder, thence to Charlotte Waters ; Adminga to Blood's Creek, and along the river-flats

of the River Stevenson to Oolabarinna!; east slope of the Stanley Tableland in Red Mulga Creek!.

HETERODENDRON OLEÆFOLIUM, *Desfontaines.* Burt Plain, Tempe Downs, and Ilpilla Gorge!; Hermannsburg (Kempe).

* DIPLOPELTIS STUARTII, *F. v. M.* McDonnell Range (E. Giles); Mount Sonder (Tietkens); stony slopes of Mount Tate!. Also Mount Conner (Tietkens).

* DODONÆA LANCEOLATA, *F. v. M.* On Mount Sonder!; Dashwood Creek (Tietkens); near Hermannsburg (Kempe).

* DODONÆA PETIOLARIS, *F. v. M.* Alice Springs (E. Flint); Krichauff Range (Kempe). Mount Gillen, Upper Finke by Mount Sonder, Glen Helen, Tempe Downs, Ilpilla Gorge, and Chandler's Range!.

DODONÆA VISCOSA, *Linné.* Sandhills by the Finke at Engoordina, Idracowra, etc.!; Hermannsburg (Kempe); Mount Sonder (Tietkens).

DODONÆA MACROZYGA, *F. v. M.* Illara Water (foliage only)!.

STACKHOUSIEÆ.

STACKHOUSIA MURICATA, *Lindley.* Gosse's Range (Schwartz); near Hermannsburg (Kempe).

* STACKHOUSIA VIMINEA, Smith. Stony slopes of Mounts Tate and Sonder!.

STACKHOUSIA MEGALOPTERA, *F. v. M.* McDonnell Range (E. Giles).

FRANKENIACEÆ.

FRANKENIA LÆVIS, *Linné.* Dry stony ground, Finke River (Stuart, Kempe); limestone surface of south slope of Mount Sonder and between Ooraminna Range and source of Francis Creek!. Common south from Engoordina!.

PLUMBAGINEÆ.

* ! PLUMBAGO ZEILANICA, *Linné.* Hermannsburg (Kempe). Shady places about rocks, Alice Springs and Simpson's Gap!.

PORTULACEÆ.

PORTULACA OLERACEA, *Linné.* Mount Zeil (Tietkens); by Mount Sonder!. Common on sandhills by the River Stevenson.

PORTULACA FILIFOLIA, *F. v. M.* Near Alice Springs and Charlotte Waters (C. Giles); Ooraminna Waterhole (Tietkens). Sandbanks by waterhole on Arumbera Creek and in Stuart's Pass!.

CLAYTONIA PTYCHOSPERMA, *F. v. M.* Upper Finke River by Mount Sonder, Carmichael Creek at Undoomoola Waterhole, and at Idracowra!; also between Mount Daniel and Charlotte Waters, and south to the River Stevenson.

CLAYTONIA BALONNENSIS, *F. v. M.* McDonnell Range (E. Giles); Hermannsburg (Kempe). Not uncommon on sandy ground throughout the region!.

CLAYTONIA PUMILA, *F. v. M.* Near McDonnell Range (E. Giles).

CLAYTONIA CORRIGIOLOIDES, *F. v. M.* Hermannsburg (Kempe).

CLAYTONIA SPERGULARINA, *F. v. M.* Sandy bed of Upper Finke and its tributaries by Mount Sonder, at Finke Gorge, and Glen of Palms!; sandy margin of Conlin's Lagoon; near Emily Gap!.

CARYOPHYLLEÆ.

SPERGULARIA RUBRA, *Pers.* Sandy margin of Conlin's Lagoon; near Emily Gap!.

POLYCARPÆA SYNANDRA, *F. v. M.* Dashwood Creek (Tietkens); Alice Springs (F. J. Gillen!). Common about the River Stevenson!.

POLYCARPÆA INDICA, *Lamarck.* Glen of Palms (E. Giles); Stuart's Pass!, Finke Gorge!, and Tempe Downs!. Also at the Goyder River!.

AMARANTACEÆ.

GOMPHRENA LANATA, *R. Br.* Hermannsburg (Kempe).

ALTERNANTHERA TRIANDRA, *Lamarck.* McDonnell Range (E. Giles); Hermannsburg (Kempe). Upper Finke by Mount Sonder!

ALTERNANTHERA NANA, *R. Br.* Darwent River Gorge, Glen Helen, and Upper Finke by Mount Sonder!; Hermannsburg (Kempe); Alice Springs (F. J. Gillen!).

*ACHYRANTHES ASPERA, *Linné.* Stokes Pass, Goyder Pass and Painta Spring!; Hermannsburg (Kempe).

PTILOTUS LATIFOLIUS, *R. Br.* "Sandstone rocks" (Tietkens); sandhills, Engoordina, Idracowra, Alice Creek and about the Lower Hugh River!; also towards sources of Goyder River!.

PTILOTUS OBOVATUS, *F. v. M.* McDonnell Range (E. Giles); Hermannsburg (Kempe); occasionally on sandy ground throughout the region!.

PTILOTUS INCANUS, *Poiret.* Hermannsburg (Kempe). Usually on stony surfaces, Glen Helen! and Mount Sonder (Tietkens); Mount Gillen, Mount Tate, and Tempe Downs!; also at the Goyder River!.

PTILOTUS ALOPECUROIDES, *F. v. M.* Widely spread on sandy soil; south side George Gill Range, etc.!; Hermannsburg (Kempe).

PTILOTUS NOBILIS, *F. v. M.* Not infrequent in bushy places, Ilpilla Gorge!, Mount Sonder! (Tietkens), etc. On rich soil in Krichauff Range (Kempe).

PTILOTUS HEMISTEIRUS, *F. v. M.* On stony ground, Ilpilla Gorge and Mount Francis; also at the Goyder River and Giddea Creek near Oodnadatta!.

*PTILOTUS PARVIFOLIUS, *F. v. M.* Stony ground, Mereenie Bluff and Darwent River Gorge!, Glen Helen and Mount Sonder!, Ooraminna Pass!; also Mount Squire and Crown Point, towards the sources of the Goyder River, Adminga Creek, and by the River Stevenson!.

*PTILOTUS EXALTATUS, *Nees.* West of Mount Sonder (Tietkens); common on stony taluses, from Crown Point on the south to Belt Range on the north!.

PTILOTUS HELIPTEROIDES, *F. v. M.* Alice Springs (F. J. Gillen!); sandy plains about Hermannsburg (Kempe); Ilpilla, east end of George Gill Range, and Mount Francis!.

PTILOTUS SCHWARTZII, *F. v. M.* Near McDonnell Range (Schwartz); stony ground, Penny's Creek!, Laurie's Creek!, Mount Tate!, Glen Helen!, Mount Sonder!, as *P. leucocomus* (Tietkens), Stuart's Pass!, gravelly knolls on Missionary Plain about Harris Creek!.

*PTILOTUS HOODII, *F. v. M.* Ilpilla Gorge, Laurie's Creek, Horn Valley and on Mount Gillen!. Previously known only from Mount Olga (E. Giles).

Euxolus Mitchelli, *F. v. M.* Common along creek-margins, but ascending hilly tracts as near summit of Mount Gillen !; stony tracts near Hermannsburg (Kempe); Ooraminna (Tietkens); also frequent by river-channels from Crown Point to Oodnadatta !.

SALSOLACEÆ.

Atriplex velutinellum, *F. v. M.* Hermannsburg (Kempe).

Atriplex nummularium, *Lindley.* Hermannsburg (Kempe).

Atriplex vesicarium, *Heward.* Hermannsburg (Kempe); Henbury !.

Atriplex spongiosum, *F. v. M.* Hermannsburg (Kempe); common at Crown Point and the Goyder and southward !.

Rhagodia spinescens, *R. Brown.* Hermannsburg (Kempe).

Rhagodia nutans, *R. Brown.* Alice Springs (Flint); Hermannsburg (Kempe); Sullivan's Creek !.

Chenopodium nitrariaceum, *F. v. M.* Upper Finke by Mount Sonder !; claypans at entrance to King's Creek !.

Chenopodium auricomum, *Lindley.* Hermannsburg (Kempe); south side of George Gill Range !.

Chenopodium carinatum, *R. Br.* Alice Springs (C. Giles); Hermannsburg (Kempe), Ilpilla Gorge !.

Chenopodium rhadinostachyum, *F. v. M.* Laura Vale (Tietkens), Hermannsburg (Kempe), Ilpilla Gorge, Glen Helen, Stuart's Pass, and on Mount Gillen !. As *C. simulans* at Mount Sonder (Tietkens).

Dysphania plantaginella, *F. v. M.* Alice Springs (C. Giles), Hermannsburg (Kempe); Finke Channel at Henbury, also at Crown Point, Glen Helen, and on Mount Gillen !.

Dysphania litoralis, *R. Brown.* Upper Finke and tributaries by Mount Sonder, and at Conlin's Lagoon !; also by River Stevenson !.

Kochia lanosa, *Lindley.* Hermannsburg (Kempe), Alice Springs (C. Giles); Laurie's and Reedy Creeks !.

Kochia triptera, *Bentham.* Alice Springs (C. Giles); Stuart's Pass !.

KOCHIA BREVIFOLIA, *R. Br.* Hermannsburg (Kempe).

KOCHIA SPONGIOCARPA, *F. v. M.* Laurie's Creek !.

KOCHIA ERIANTHA, *F. v. M.* Hermannsburg (Kempe).

KOCHIA VILLOSA, *Lindley.* Hermannsburg (Kempe); Ilpilla and Stuart's Pass !.

KOCHIA SEDIFOLIA, *F. v. M.* South side of George Gill Range and plain west of Carmichael's Crag !.

KOCHIA APHYLLA, *R. Br.* Hermannsburg (Kempe), and loamy plains by George Gill Range and Vale of Tempe !.

BABBAGIA DIPTEROCARPA, *F. v. M.* Hermannsburg (Kempe); also at Goyder River and Dalhousie Springs !

BASSIA SCLEROLÆNOIDES, *F. v. M.* Hermannsburg (Kempe); also Crown Point !.

BASSIA UNIFLORA, *F. v. M.* Ilpilla Gorge !.

BASSIA DIACANTHA, *F. v. M.* Hermannsburg (Kempe); also at the Goyder River !.

BASSIA LANICUSPIS, *F. v. M.* Hermannsburg (Kempe); also Charlotte Waters (F. Giles).

BASSIA LUEHMANNI, *F. v. M.* Hermannsburg (Schwartz).

BASSIA PARADOXA, *F. v. M.* Hermannsburg (Kempe). Widely dispersed throughout the region; but more frequent about Crown Point, Goyder River and southward !.

BASSIA QUINQUECUSPIS, *F. v. M.* Ilpilla Creek !; also at the Goyder River !.

BASSIA BIRCHII, *F. v. M.* Base of Belt Range, Ilpilla !.

BASSIA ECHINOPSILA, *F. v. M.* Ilpilla; also at the Goyder River !.

ENCHYLÆNA TOMENTOSA, *R. Br.* River Finke at Hermannsburg (Kempe) and Running Water !; Alice Springs (F. J. Gillen !).

SALICORNIA ROBUSTA, *F. v. M.* Stony ground between James Range and Alice Creek !.

SALICORNIA LEIOSTACHYA, *Bentham.* Hermannsburg (Kempe); Idracowra !.

|| SALSOLA KALI, *Linné.* Common from Oodnadatta to Crown Point, thence less frequent, but widely spread on loam flats and stony ground !.

FICOIDEÆ.

AIZOON ZYGOPHYLLOIDES, *F. v. M.* VAR. with large rhomboid-ovate leaves, larger flowers on longer pedicels, Chandler's Range ! ; also at Crown Point !.

ZALEYA DECANDRA, *Burmann.* Finke River (Kempe) ; Hope Valley beyond Carmichael Crag, Ooraminna Waterhole ; also Opossum Waterhole on the Stevenson !.

|| TRIANTHEMA CRYSTALLINA, *Vahl.* Stuart's Pass ! ; also Crown Point, valley of the Goyder and southward !.

TRIANTHEMA PILOSA, *F. v. M.* Mount Sonder (Tietkens) ; River Finke (Kempe) ; River Hugh at Alice Well ; also the Goyder and Stevenson Rivers !

|| MOLLUGO HIRTA, *Thunberg.* Mount Sonder (Tietkens) ; Stuart's Pass, Horn Valley, and Alice Well ; also sandhills by the Goyder and Stevenson Rivers !

MOLLUGO ORYGIOIDES, *F. v. M.* Conlin's Lagoon !

|| MOLLUGO CERVIANA, *Séringe.* Hermannsburg (Kempe) ; Glen Helen (Tietkens). Sandhills and sandy creek beds, Idracowra, Henbury, by Mount Sonder, Stuart's Pass, and Alice Well ! ; Alice Springs (F. J. Gillen !).

POLYGONACEÆ.

|| POLYGONUM PLEBEIUM, *R. Br.* Mount Razorback (Tietkens) ; Hermannsburg (Kempe). Upper Finke by Mount Sonder, Finke Gorge, Conlin's Lagoon, and River Hugh at Alice Well !.

|| POLYGONUM MINUS, *Hudson.* With narrow lanceolate leaves, marsh at Reedy Creek !.

MUEHLENBECKIA CUNNINGHAMII, *F. v. M.* Hermannsburg (Kempe). South side of George Gill Range and Conlin's Lagoon !.

PHYTOLACCEÆ.

GYROSTEMON RAMULOSUS, *Desfontaines.* Glen of Palms (E. Giles) ; Glen Edith (Tietkens). Sandhills at Idracowra, and between the Hugh River and Engoordina ; also south to the Goyder River !.

Codonocarpus cotinifolius, *F. v. M.* Glen Helen, Mount Sonder and Dashwood Creek (Tietkens); Hermannsburg (Kempe). By the Finke at Henbury, by the Walker at Tempe Downs, and valley of Alice Creek, near Hugh River; also at the Goyder River !.

NYCTAGINEÆ.

Boerhaavia diffusa, *Linné.* Glen of Palms (Kempe); Bond and Painta Springs (Tietkens). Wide spread, on loamy flats and ascending to high elevations, as on Mount Gillen !.

Boerhaavia plantaginea, *Cavanilles.* Lake Macdonald (Tietkens).

THYMELEÆ.

Pimelea trichostachya, *Lindley.* Gosse's Range (E. Giles); stony rises, Hermannsburg (Kempe); Ilpilla Gorge, east end of George Gill Range, and Stuart's Pass !.

Pimelea microcephala, *R. Brown.* Hermannsburg (Kempe); Horn Valley !; also Crown Point to the River Stevenson !.

LEGUMINOSÆ.

Brachysema Chambersii, *F. v. M.* Between the Rivers Stevenson and Finke (Stuart); McDonnell Range (E. Giles); sandhills, Rudall's Creek (Kempe); at Ilpilla, between Laurie's Creek and Glen Edith, and in the valley of Carmichael Creek !; between George Gill Range and Lake Amadeus (Spencer !). Extends to Barrow Range (Elder Exped.)

Gastrolobium grandiflorum, *F. v. M.* Glen of Palms (E. Giles); Alice Springs (*Herb. F. v. M.*); south side of George Gill Range, and on Mount Sonder !; also at Ayers Rock (Spencer !).

Isotropis atropurpurea, *F. v. M.* Glen of Palms (E. Giles); and everywhere about Hermannsburg (Kempe); Alice Springs (F. J. Gillen !).

Isotropis Wheeleri, *F. v. M.* Sandhills at Hermannsburg (Kempe).

* Mirbelia oxyclada, *F. v. M.* McDonnell Range (E. Giles); Krichauff Range (Kempe); Bagot's Creek and other ravines in George Gill Range; rocky slopes of Mount Tate !.

* BURTONIA POLYZYGA, *Bentham.* McDonnell Range (E. Giles), south-west slope of Mount Tate !.

DAVIESIA ARTHROPODA, *F. v. M.* Sandhills, Eagle Plain near Palmer River !.

TEMPLETONIA EGENA, *Bentham.* Hermannsburg (Kempe); sandhills at Idracowra, George Gill Range, and from Engoordina to the Hugh River !.

CROTALARIA NOVÆHOLLANDIÆ, *De Cand.*, var. *lasiophylla.* Sandy soil Ooraminna Pass !, near McDonnell Range (Flint, F. v. M. in litteris, 19–9–'91).

CROTALARIA CUNNINGHAMII, *R. Br.* Hermannsburg (Kempe); sandhills at Idracowra, Carmichael Creek, between Ooraminna and James Ranges, and by the River Hugh at Alice Well !; also Mount Humphries (Stuart) and River Stevenson !

*‖ CROTOLARIA MEDICAGINEA, *Lamarck.* Hermannsburg (Kempe); Bond Springs, Mount Sonder and Laura Vale (Tietkens); sources of the Carmichael and Darwent Creeks by Mereenie Bluff !; Horn Valley, Ilpilla Gorge and Mount Francis !; Paddy's Hole in Hart Range (Watt !).

‖ CROTALARIA INCANA, *Linné.* Redbank Creek !, under Mount Sonder (Tietkens).

CROTALARIA DISSITIFLORA, *Bentham*, var. *eremæa.* Sandy ground and alluvial flats, common !; McDonnell Range (Stuart); Laura Vale and Gill's Creek (Tietkens); Hermannsburg (Kempe); Upper Finke and tributaries by Mount Sonder !; Alice Springs !.

LOTUS AUSTRALIS, *Andrews.* Hermannsburg (Kempe); Mount Sonder and Laura Vale (Tietkens); Carmichael Creek and by Mereenie Bluff !.

PSORALEA ERIANTHA, *Bentham.* Hermannsburg (Kempe); sandhills by the Finke at Engoordina and between James Range and Hugh River !.

PSORALEA BALSAMICA, *F. v. M.* McDonnell Range (Stuart).

PSORALEA PATENS, *Lindley.* Loamy flats subject to inundation and by river banks, Upper Finke and tributaries, etc. !; Hermannsburg (Kempe).

‖ INDIGOFERA LINIFOLIA, *Retzius.* Hermannsburg (Kempe); Laura Vale (Tietkens); bed of Ilpilla Creek, Mereenie Bluff, by Belt Range, Goyder Pass !.

‖ INDIGOFERA ENNEAPHYLLA, *Linné.* Hermannsburg (Kempe); near the junction of the Rivers Finke and Palmer, and by Belt Range !.

| INDIGOFERA VISCOSA, *Lamarck.* Brinkley Bluff (Stuart); Hermannsburg (Kempe); Bond Springs, Mount Sonder, &c. (Tietkens); Rudall's Creek by Mereenie Bluff, by Belt Range, Ooraminna Pass, also sandhills by River Stevenson!.

| INDIGOFERA HIRSUTA, *Linné.* Mount Sonder (Tietkens).

INDIGOFERA MONOPHYLLA, *De Cand.* McDonnell Range (E. Giles); Laura Vale and Gill's Creek (Tietkens); Mereenie Bluff!.

INDIGOFERA BREVIDENS, *Bentham.* McDonnell Range (Stuart); Glen of Palms! (E. Giles) and Krichauff Range (Kempe); Henbury, Ilpilla, east end of George Gill Range, slopes of Mount Francis and Mount Sonder, Finke Gorge and Horn Valley, Stuart's Pass and Mount Gillen!

I. coronillifolia, Cunningham, from McDonnell Range (Stuart), referred to in Fl. Aust., vol. ii., p. 201, belongs probably to the canescent variety of *I. brevidens*, which is restricted to rocky ground.

PTYCHOSEMA TRIFOLIOLATUM, *F. v. M.* Hermannsburg (Kempe); Ooraminna Pass by Hell Gates, and between there and James Range!.

TEPHROSIA SPHÆROSPORA, *F. v. M.* Hermannsburg (Kempe); slopes of Mount Tate and Ooraminna Pass!.

TEPHROSIA PURPUREA, *Persoon.* Stony ground, Hermannsburg (Kempe); Ilpilla, Tempe Downs, Reedy Creek, Stokes Pass Gorge, Horn Valley, Glen Helen, Finke Gorge, and Stuart's Pass!.

SWAINSONIA PHACOIDES, *Bentham.* McDonnell Range (E. Giles); Hermannsburg (Kempe). Alluvial flats at Alice Well!

SWAINSONIA BURKEI, *F. v. M.* McDonnell Range (E. Giles); sandy and loamy flats, Glen Helen!

SWAINSONIA OLIGOPHYLLA, *F. v. M.* North-west interior (Stuart).

SWAINSONIA CANESCENS, *F. v. M.* Somewhat less downy than the type (F. v. M. in litteris). North side of Finke Gorge; margin of River Todd, north side of Heavitree Gap!.

SWAINSONIA CYCLOCARPA, *F. v. M.* Near McDonnell Range (Schwartz).

SWAINSONIA UNIOFOLIOLATA, *F. v. M.* At Kamarand's Well, between George Gill Range and Lake Amadeus (Spencer!).

Swainsonia microphylla, *A. Gray.* McDonnell Range (Schwartz); valley of the Finke by Mount Sonder, and plain north of Ooraminna Pass !.

|| Æschynomene Indica, *Linné.* Banks of the Finke at Henbury !; also by Adminga Creek and waterholes of the River Stevenson !.

Glycine clandestina, *Wendland.* Hermannsburg (Kempe); Blood's Range (Tietkens); Bagot's Creek and ravines of Mount Tate !.

Glycine sericea, *Bentham.* Gill's Creek (Tietkens); Glen Helen, and by the Finke River near Mount Sonder !.

* Kennedya prorepens, *F. v. M.* Near (on !) Mount Sonder (Tietkens). Extends to Barrow Range, W.A. (Elder Exped.).

* Erythrina vespertilio, *Bentham.* McDonnell Range and Mount Udor (E. Giles); Krichauff Range (Kempe); Mount Sonder ! (Tietkens); Finke Gorge and Mount Francis !.

Vigna lanceolata, *Bentham.* Painta Spring and Glen Helen (Tietkens); Alice Well at the Hugh River; also at Adminga Creek and by the River Stevenson !.

|| Rhynchosia minima, *De Cand.* Stony places near Hermannsburg (Kempe); Mount Sonder and Glen Helen (Tietkens); source of the Darwent River and by Belt Range !.

|| Cassia Sophera, *Linné.* River beds, Hermannsburg (Kempe); Mount Sonder (Tietkens); Tempe Downs !.

Cassia venusta, *F. v. M.* Glen of Palms and McDonnell Range (E. Giles); Ilpilla, Reedy Creek, Missionary Plain by Pine Point, by Belt Range and Stuart's Pass !.

Cassia notabilis, *F. v. M.* McDonnell Range (E. Giles).

Cassia pleurocarpa, *F. v. M.* McDonnell Range (E. Giles); Glen Helen (Tietkens); Hermannsburg (Kempe); R. Walker Gorge at Tempe Downs, Alice Well, and extending to west and north on sandy flats by river channels !; Crown Point !.

* Cassia glutinosa, *De Cand.* Rocky tracts, Hermannsburg (Kempe); Ilpilla Gorge, Mount Francis, and Spencer Gorge off Stuart's Pass !.

* Cassia pruinosa, *F. v. M.* Rocky declivities at Penny Creek, in George Gill Range, and of Mereenie Bluff !.

CASSIA PHYLLODINEA, *R. Brown.* River flats of the Upper Finke by Mount Sonder, Ilpilla and Bagot's Creek !.

CASSIA EREMOPHILA, *Cunn.* Hermannsburg (Kempe); Mount Gillen !.

CASSIA ARTEMISIOIDES, *Gaud.* Hermannsburg (Kempe); by Belt Range !; Alice Springs (F. J. Gillen !).

CASSIA STURTII, *R. Brown.* Tempe Downs, slopes of Mount Sonder and Mount Francis !.

CASSIA DESOLATA, *F. v. M.* Hermannsburg (Kempe), Laura Vale (Tietkens); by Belt Range, Horn Valley and Stuart's Pass !.

PETALOSTYLIS LABICHOIDES, *R. Brown.* Glen of Palms (bed of River Finke !) (E. Giles); ranges, Hermannsburg (Kempe); Mount Sonder and Glen Helen (Tietkens); Tempe Downs, Parke's Gap, and between the Hugh River and Engoordina !.

NEPTUNIA MONOSPERMA, *F. v. M.* Near Hermannsburg (Kempe).

ACACIA PATENS, *F. v. M.* McDonnell Range (E. Giles), Mount Sonder (Tietkens), Hermannsburg (Kempe); sand-plains, Laurie's Creek to Glen Edith, valley of Carmichael Creek, Missionary Plain towards Owen's Spring, Ooraminna Pass and towards James Range, thence to the Hugh River and Engoordina and Crown Point !

ACACIA TETRAGONOPHYLLA, *F. v. M.* Hermannsburg (Kempe); Tempe Downs, and sparsely distributed throughout the region !.

ACACIA SESSILICEPS, *F. v. M.* Hermannsburg (Kempe); base of Mount Sonder, between Hermannsburg and Ellery Creek, Alice Creek, also Charlotte Waters !.

* ACACIA LYCOPODIFOLIA, *Cunn.* McDonnell Range (E. Giles); rock surfaces, Ilpilla Gorge, slopes of Mount Tate, on Mount Sonder, on Mount Francis, Horn Valley, Stuart's Pass !.

* ACACIA SPONDYLOPHYLLA, *F. v. M.* Glen of Palms and McDonnell Range (E. Giles), Mount Sonder (Tietkens).

ACACIA MINUTIFOLIA, *F. v. M.* Hermannsburg (Kempe).

ACACIA ULICINA, *Meissner,* var. *oxyclada.* West of McDonnell Range (Tietkens).

Acacia Sentis, *F. v. M.* Hermannsburg (Kempe); river flats by Mount Sonder, and generally distributed !.

Acacia frumentacea, *Tate,* n. sp. Reedy Creek and by Mount Sonder; alluvial flats about Alice Creek and general thence south to Charlotte Waters !.

Acacia notabilis, *F. v. M.* Mount Sonder and Gill's Creek (Tietkens); Carmichael Creek by Mereenie Bluff !; Laurie's Creek !.

Acacia salicina, *Lindley.* McDonnell Range (E. Giles), Hermannsburg (Kempe), Mount Sonder (Tietkens). Very general, on rich alluvial flats attaining to 40ft. and 50ft. high !.

* Acacia strongylophylla, *F. v. M.* Rocky ground; Glen of Palms (E. Giles), Palm Creek !, and Hermannsburg (Kempe); Mount Sonder ! (Tietkens); Mount Tate, Stuart's Pass, and Ilpilla Gorge !.

Acacia pyrifolia, *De Cand.* Gill's Creek, Laura Vale, and Warman Rocks (Tietkens); base of Mount Francis !.

Acacia estrophiolata, *F. v. M.* Hermannsburg (Kempe).

Acacia coriacea, *De Cand.* South McDonnell Range !.

Acacia dictyophleba, *F. v. M.* Hermannsburg (Kempe), north of Mount Harris (Tietkens); Mounts Tate and Gillen !; near Gosse Range (Spencer). Chiefly on sandhills, Idracowra, Henbury, Chambers Pillar, Engoordina to Mount Squire and Crown Point. Var. with narrow oblong-lanceolate leaves under one inch; by Mount Francis !.

Acacia lysiphloia, *F. v. M.* Hermannsburg (Kempe).

Acacia stipuligera, *F. v. M.* Near McDonnell Ranges (E. Giles).

Acacia acradenia, *F. v. M.* North of Mount Harris (Tietkens).

Acacia cyperophylla, *F. v. M.* Warman Rocks (Tietkens), Mount Udor (E. Giles), from description "Geogr. Travels," p. 32; also by margin of creeks flowing on scarped face of Stanley Tableland to the Stevenson River, and on the east slope on Red Mulga Creek !.

Acacia aneura, *F. v. M.* Throughout the region, forming dense scrubs and ascending to high elevations; in rich soils attaining to 30ft. or 40ft. high !. Hermannsburg (Kempe).

ACACIA KEMPEANA, *F. v. M.* Finke River (Kempe); Laurie's and Carmichael Creeks !. Common in the valley of the Hugh, thence to Engoordina and south to the Goyder River !.

ACACIA DORATOXYLON, *Cunn.* Twelve miles south-east of Gill's Creek (Tietkens); also Mount Olga (Tietkens) and Ayers Rock (Spencer !).

* ACACIA COWLEANA, *Tate*, n. sp. Slopes of Mount Tate, near source of Carmichael Creek, slopes of Mount Francis !.

ACACIA FARNESIANA, *Willdenow.* Chiefly in the channels of creeks, Henbury, Tempe Downs, Rudall Creek, Goyder Pass, Upper Finke, and tributaries by Mount Sonder !; Hermannsburg (Kempe); Mount Sonder (Tietkens); also Red Mulga Creek near Dalhousie Springs !.

CRASSULACEÆ.

| TILLÆA VERTICILLARIS, *De Cand.* Henbury !, Conlin's Lagoon !.

SALICARIEÆ.

ROTALA VERTICILLARIS, *Linné.* West of McDonnell Range (Tietkens); Carmichael Creek !.

ROTALA DIANDRA, *F. v. M.* Near McDonnell Range (Dittrich).

AMMANNIA MULTIFLORA, *Roxburgh.* Mount Sonder (Tietkens).

AMMANNIA AURICULATA, *Willdenow.* Common by river margins, Mount Sonder ! (Tietkens); Stuart's Pass, Carmichael Creek, and south to Adminga Creek and River Stevenson !.

| LYTHRUM HYSSOPIFOLIA, *Linné.* Margin of Conlin's Lagoon !.

HALORAGEÆ.

LOUDONIA AUREA, *Lindley.* Sand plain bordering George Gill Range and around Glen Edith !.

HALORAGIS GOSSEI, *F. v. M.* Glen of Palms (E. Giles) and Hermannsburg (Kempe); Alice Springs (C. Giles); Chambers Pillar !.

HALORAGIS ODONTOCARPA, *F. v. M.* Mulga scrub four miles north-east from Glen Edith !.

HALORAGIS ASPERA, *Lindley.* Hermannsburg (Kempe); slopes of Mount Sonder! (Tietkens); by Belt Range, Henbury!

MYRIOPHYLLUM VERRUCOSUM, *Lindley.* River Finke, near Hermannsburg (Kempe), at Palm Creek, Running Water, and Henbury!; Darwent River!.

MYRTACEÆ.

CALYCOTHRIX LONGIFLORA, *F. v. M.* McDonnell Range (E. Giles); Hermannsburg (Kempe); north of Mount Harris (Tietkens); sandhills between Bagot's Creek and Winnall Range, and north-east from Glen Edith!.

THRYPTOMENE MAISONEUVII, *F. v. M.* River Finke (E. Giles); near Mount Sonder, Glen Edith, and Gill's Creek (Tietkens); sandhills chiefly between Sullivan's Creek and Idracowra; Eagle Plain, Palmer River; between Laurie's Creek and Glen Edith, thence into the valley of Carmichael Creek; between Ooraminna Pass and James Range, thence to Hugh River and south to Crown Point!; occasionally on rocky declivities, as at Tempe Downs, Bagot's Creek, etc.!.

THRYPTOMENE FLAVIFLORA, *F. v. M.* McDonnell Range (E. Giles); sand country south side of George Gill Range, and between Laurie's Creek and Glen Edith!.

* BÆCKEA POLYSTEMONEA, *F. v. M.* Brinkley Bluff (Stuart); in McDonnell Range (E. Giles); Mount Harris (Tietkens).

MELALEUCA PARVIFLORA, *Lindley.* Hermannsburg (Kempe).

MELALEUCA GLOMERATA, *F. v. M.* River Finke at Hermannsburg (Kempe); river banks throughout the region!.

MELALEUCA, sp. A tree forty feet high, bark papery, leaves cylindrical, glaucous, and longer than *M. glomerata*; Spencer Gorge!.

EUCALYPTUS MICROTHECA, *F. v. M.* McDonnell Range (Stuart); flooded ground by River Todd at Heavitree Gap; but abundant south of Charlotte Waters.

* EUCALYPTUS PACHYPHYLLA, *F. v. M.* Glen of Palms (E. Giles) and Krichauff Range (Kempe); gorge of Reedy Creek, ravine on south side of Mount Tate, on Mount Sonder!.

EUCALYPTUS OLEOSA, *F. v. M.* Hermannsburg (Kempe); Illamurta!; constituting dense scrubs on the taluses of the ranges as about the sources of

Carmichael Creek, Glen Helen, Mount Sonder, Horn Valley, and south flank of McDonnell Range in the Valley of the Hugh !.

EUCALYPTUS OLDFIELDII, *F. v. M.* Hermannsburg (Kempe); sandhills by junction of Palmer and Walker, Missionary Plain by Pine Point, slopes of Mount Francis !.

VAR. with leaves oval-oblong to ovate-obcordate, one to one-and-a-quarter inches long. Slopes of Mount Sonder !.

EUCALYPTUS TESSELLARIS, *F. v. M.* Hermannsburg (Kempe); sandy and alluvial flats, Henbury, south side of George Gill Range, by Belt Range, by the Lower Hugh River and elsewhere, extending south to Crown Point, the Goyder and Charlotte Waters !.

EUCALYPTUS ROSTRATA, *Schleckt.* River channels throughout the region !; Hermannsburg (Kempe).

EUCALYPTUS GAMOPHYLLA, *F. v. M.* Hermannsburg (Kempe); Mount Sonder (Tietkens); gregarious chiefly on sandy soil, as about junction of Finke and Palmer Rivers, valley of the Walker; but also on stony taluses and rocky declivities, as at Mount Tate, Belt Range and Mount Gillen !.

EUCALYPTUS SETOSA, *Schauer.* Laura Vale and Gill's Creek (Tietkens).

* EUCALYPTUS TERMINALIS, *F. v. M.* Hermannsburg (Kempe); widely distributed, chiefly on rocky declivities and tablelands, Tempe Downs to George Gill Range, Mereenie Escarpment to Mount Sonder and Stuart's Pass, Mount Gillen to James Range !.

EUCALYPTUS EUDESMOIDES, *F. v. M.* Sandhills between Bagot's Creek and Lake Amadeus (Spencer !).

RHAMNACEÆ.

VENTILAGO VIMINALIS, *Hooker.* Hermannsburg (Kempe); Goyder Pass and Burt Plain !.

* CRYPTANDRA SPATHULATA, *F. v. M.* Glen of Palms (E. Giles) and Krichauff Range (Kempe); Laurie's Creek !.

UMBELLIFERÆ.

* HYDROCOTYLE TRACHYCARPA, *F. v. M.* Near Hermannsburg (Kempe); shaded rocks, Bagot's Creek, Mount Tate, Horn Valley and Finke Gorge !.

* Didiscus Gillenæ, *Tate*, n. sp. On Mount Gillen near Alice Springs !.

Didiscus glaucifolius, *F. v. M.* River Finke (Stuart); Hermannsburg (Kempe); Glens Helen and Edith (Tietkens); not infrequent in alluvial soil, George Gill Range, Chambers Pillar, etc. !

* Actinotus Schwartzii, *F. v. M.* On Mount Sonder (Schwartz).

|| Daucus brachiatus, *Sieber.* Hermannsburg (Kempe); margins of creeks, Henbury, Glen Helen, Upper Finke by Mount Sonder !.

SANTALACEÆ.

Exocarpos spartea, *R. Brown.* Ranges and sandhills about Hermannsburg (Kempe); sand plain off Bagot's Creek, between Glen Edith and Carmichael Creek, and valley of Upper Finke by Mount Sonder !.

* Anthobolus exocarpoides, *F. v. M.* McDonnell Range (E. Giles), on rocky slopes of Mount Tate !; extends to Cavenagh Range (Elder Exped.).

Santalum lanceolatum, *R. Brown.* Hermannsburg (Kempe), Henbury and Illamurta !.

Santalum acuminatum, *A. de Cand.* McDonnell Range (E. Giles), Hermannsburg (Kempe). Of frequent occurrence in the alluvial bottoms of the river gorges and alluvial flats of valleys, such as at George Gill Range and the Upper Finke !.

LORANTHACEÆ.

Loranthus Exocarpi, *Behr.* Hermannsburg (Kempe), near Mount Sonder (Tietkens) Widely dispersed throughout the region !.

Loranthus linophyllus, *Fenzl.* Hermannsburg (Kempe). Widely dispersed !.

Loranthus gibberulus, *Tate.* Glen Helen (Tietkens); on *Grevillea striata* at Mount Francis, Goyder Pass, Burt Plain, and by River Todd at Alice Springs !; on *Grevillea agrifolia* at Palm Creek !; on *Hakea leucoptera*, between James Range and Alice Creek !.

Loranthus pendulus, *Sieber.* Hermannsburg (Kempe), Glen Edith (Tietkens); Stuart's Pass !.

Loranthus Quandang, *Lindley.* Hermannsburg (Kempe). Ranging with its chief host-plant, *Acacia aneura* !.

PROTEACEÆ.

Grevillea pterosperma, *F. v. M.* A wide-spreading tree of about twenty feet high; sand-plain off Bagot's Creek !.

Grevillea stenobotrya, *F. v. M.* McDonnell Range (E. Giles).

Grevillea eriostachya, *Lindley.* Glen Edith (Tietkens), as *G. chrysodendron;* sand-plain between Glen Edith and Carmichael Creek !.

Grevillea juncifolia, *Hooker.* McDonnell Range and Glen of Palms (E. Giles), ranges by Hermannsburg (Kempe), Engoordina (Tietkens); Chambers Pillar, Illara Water, and by junction of Palmer and Walker Rivers !.

Grevillea angulata, *R. Brown.* Hermannsburg (Kempe).

Grevillea Wickhami, *Meissner.* Glen of Palms, Gosse's Range, and McDonnell Range (E. Giles).

*Grevillea agrifolia, *Cunn.* McDonnell Range (Stuart), Glens Edith and Farewell (Tietkens). Rocky ravines and declivities, Ilpilla, Reedy and Penny's Creeks, Mount Tate, Mount Francis, Mount Sonder, Stuart's Pass, Mount Gillen and Palm Creek !.

Grevillea striata, *R. Brown.* Sand-flats near Idracowra, Henbury, south side of George Gill Range, by Belt Range, valley of the Upper Finke, Goyder Pass, Burt Plain, valley of the Todd River near Alice Springs !; Hermannsburg (Kempe).

Grevillea nematophylla, *F. v. M.* Sandhills and plains, Chambers Pillar, south side of George Gill Range, between James Range and River Hugh, thence to Engoordina, Crown Point and Charlotte Waters !.

Hakea lorea, *R. Brown.* Glen of Palms and McDonnell Range (E. Giles). Sandy or loamy soil, not infrequent, as at Henbury and Carmichael Valley !; more common about Crown Point, in the valley of the Goyder, thence to Charlotte Waters !.

Hakea purpurea, *Hooker.* Between Lakes Amadeus and Macdonald (Tietkens).

Hakea leucoptera, *R. Brown.* Loam flats and sandhills, widely distributed throughout the Larapintine region !; Hermannsburg (Kempe).

Hakea multilineata, *Meissner.* On Mount Sonder ! (Schwartz); also on Boggy Flat between Goyder River and Mount Daniel; north side of Crown Point !.

RUBIACEÆ.

Oldenlandia galioides, *F. v. M.* West of McDonnell Range (Tietkens).

Oldenlandia tillæacea, *F. v. M.* Carmichael Creek and Mount Francis !.

Canthium latifolium, *F. v. M.* Central Australia (Stuart); McDonnell Range (E. Giles); stony ground chiefly in the ranges, near Hermannsburg (Kempe); between Running Waters and Ilpilla, south side of George Gill Range, Glen Helen, and elsewhere !. Extends south to Arkaringa Valley (Elder Exped.).

Pomax umbellata, *Solander.* McDonnell Range (E Giles); Hermannsburg (Kempe) Sandhills at Idracowra, rock surface at Tempe Downs, and in Bagot's Creek Gorge !.

CUCURBITACEÆ.

‖ Cucumis Chate, *Linné.* McDonnell Range (E. Giles); Hermannsburg (Kempe); south side of George Gill Range, Stuart's Pass !; also by River Stevenson and at Gidia Creek near Oodnadatta !.

‖ Melothria Maderaspatana, *Cognx.* Hermannsburg (Kempe); near Mount Sonder, Engoordina (Tietkens). Common in bushy places, Stuart's Pass, Horn Valley !, etc.

COMPOSITÆ.

Brachycome ciliaris, *Lessing.* Running Water !, Mount Francis !, Conlin's Lagoon !.

* Var. *glandulosa.* Branches lax, spreading two and three feet, flowers blue or white, leaves varying from pinnate to linear-lanceolate, with long linear serratures. Saxatile at Tempe Downs, Reedy Creek, Glen Helen Gorge and Palm Creek !.

Minuria leptophylla, *De Cand.* McDonnell Range (C. Giles); Ilpilla, slopes of Mereenie Bluff, sand-plain north-east of Glen Edith, and between the Todd and Ooraminna Pass !; Alice Springs (F. J. Gillen !).

MINURIA CUNNINGHAMII, *Bentham.* Hermannsburg (Kempe); Idracowra, junction of Palmer and Finke Rivers, Stokes Pass !.

CALOTIS DENTEX, *R. Brown.* Mallee scrub, a few miles north-east from Glen Edith !.

CALOTIS CYMBACANTHA, *F. v. M.* Ooraminna Pass !; also at the Goyder River !.

CALOTIS ERINACEA, *Steetz.* Sub-shrubby, spreading hemispherically to about three feet diameter. Sandhills at Idracowra, Reedy Creek, River Hugh at Alice Well, thence south to Crown Point, the Goyder and Stevenson Rivers !.

CALOTIS LAPPULACEA, *Bentham.* Sandy ground, Hermannsburg (Kempe); Carmichael Creek !.

CALOTIS MICROCEPHALA, *Bentham.* Hermannsburg (Kempe).

CALOTIS LATIUSCULA, *F. v. M.* and *Tate.* Near Finke River (*teste* F. v. M.); Sullivan's Creek, south side of George Gill Range and Glen of Palms !.

CALOTIS PLUMULIFERA, *F. v. M.* Carmichael Creek (with several rows of ray-florets); Glen Helen !

CALOTIS PORPHYROGLOSSA, *F. v. M.* Conlin's Lagoon, near Alice Springs; also by the River Stevenson !.

CALOTIS HISPIDULA, *F. v. M.* Hermannsburg (Kempe); east end of George Gill Range, Carmichael Creek, Finke River by Mount Sonder !.

CALOTIS KEMPEI, *F. v. M.* Perennial, spreading to about two feet high. Hermannsburg (Kempe), Engoordina, and also abundant at the Goyder River !

ASTER MITCHELLI, *F. v. M.* McDonnell Range (E. Giles), Hermannsburg (Kempe).

* ASTER FERRESII, *F. v. M.* Brinkley Bluff (Stuart), McDonnell Range (E. Giles), Krichauff Range (Kempe); Bagot's Creek, Belt Range, and Stuart's Pass !.

* ASTER MEGALODONTUS, *F. v. M.* Flowers blue. Chandler Range, Ilpilla Gorge, Tempe Downs, George Gill Range, Mount Sonder, Goyder Pass, Finke Gorge, Stuart Pass, Mount Gillen, Ooraminna Pass !.

VITTADINIA AUSTRALIS, *A. Richard.* Sandy soil, Hermannsburg (Kempe); Tempe Downs (with 3-lobed leaves), south side of George Gill Range, Upper Finke by Mount Sonder !

* VITTADINIA SCABRA, *De Cand.* Ilpilla Gorge, Tempe Downs, Darwent River Gorge, Finke Gorge !.

PODOCOMA CUNEIFOLIA, *R. Brown.* McDonnell Range (C. Giles); Mount Sonder (Tietkens); near Hermannsburg (Kempe); on limestone rubble east of George Gill Range and by Mereenie Bluff; Engoordina (occasionally with white flowers) !.

PLUCHEA TETRANTHERA, *F. v. M.* Hermannsburg (Kempe).

PLUCHEA EYREA, *F. v. M.* McDonnell Range (E. Giles); Hermannsburg (Kempe); usually on marshy ground, Illamurta, Bagot's Creek, ravine of Mount Tate, Redbank Gorge, Finke Gorge, Stuart's Pass, Painta Spring !.

* PLUCHEA SQUARROSA, *Bentham.* Bagot Creek in George Gill Range, Palm Creek in Krichauff Range, Redbank Gorge, Glen Helen !.

PTERIGERON LIATROIDES, *Bentham.* Laura Vale (Tietkens); Henbury and Ilpilla Gorge !.

PTERIGERON MICROGLOSSUS, *Bentham.* Sandy tracts, Hermannsburg (Kempe).

PTERIGERON DENTATIFOLIUS, *F. v. M.* Between McDonnell Range and Charlotte Waters (C. Giles).

‖ EPALTES AUSTRALIS, *Lessing.* Reedy Creek in George Gill Range !; also Crown Point and River Stevenson !.

* PTEROCAULON BILLARDIERI, *F. v. M.* Hermannsburg (Kempe); Belt Range, Horn Valley, Finke Gorge, and on Mount Gillen !.

PTEROCAULON SPHACELATUS, *Bentham.* McDonnell Range (Stuart); also Crown Point !.

‖ GNAPHALIUM LUTEO-ALBUM, *Linné.* Common throughout the region !; Hermannsburg (Kempe), Painta Spring (Tietkens).

‖ GNAPHALIUM JAPONICUM, *Thunberg.* Finke Gorge !.

‖ GNAPHALIUM INDICUM, *Linné.* Hermannsburg (Kempe).

IXIOLÆNA TOMENTOSA, *Sonder* and *F. v. M.* Hermannsburg (Kempe); sandhills, Tempe Downs, Darwent River, Alice Creek, and Lower Hugh River !.

PODOLEPIS CANESCENS, *Cunn.* Sandhills, Hermannsburg (Kempe); Ooraminna Pass and between there and James Range !.

PODOLEPIS SIEMSSENII, *F. v. M.* Stuart's Pass by Brinkley Bluff !.

WAITZIA CORYMBOSA, *Wendland.* Ooraminna Pass !.

HELIPTERUM FLORIBUNDUM, *De Cand.* Hermannsburg (Kempe); junction of Finke and Palmer Rivers, Carmichael Creek !; Alice Springs (F. J. Gillen !).

HELIPTERUM STIPITATUM, *F. v. M.* River Finke (Stuart), McDonnell Range (E. Giles); sandhills, Hermannsburg (Kempe), Running Water, Ilpilla, and between Ooraminna and James Ranges !. Extends to Barrow Range and Victoria Desert (Elder Exped.).

HELIPTERUM INCANUM, *De Cand.* Stony ground, Hermannsburg (Kempe); Ilpilla Gorge and Mount Sonder !.

HELIPTERUM FITZGIBBONI, *F. v. M.* Hermannsburg (Kempe), Tempe Downs (Thornton), Mount Squire !; also west of Eringa (Tietkens). Extends to Barrow Range and Victoria Desert (Elder Exped.).

HELIPTERUM HYALOSPERMUM, *F. v. M.* Finke Gorge !.

HELIPTERUM STRICTUM, *Bentham.* Stuart's Pass by Brinkley Bluff !.

HELIPTERUM CHARSLEYÆ, *F. v. M.* Hermannsburg (Kempe); clay flats and flooded ground, sources of Laurie's and Rudall's Creeks, Carmichael Creek, Darwent River, Glen Helen, Upper Finke by Mount Sonder, Conlin's Lagoon, and valley of the Upper Hugh River !; also by the River Stevenson !.

HELIPTERUM MOSCHATUM, *Bentham.* Hermannsburg (Kempe), Engoordina !.

HELIPTERUM TIETKENSI, *F. v. M.* Hermannsburg (Kempe); Darwent River, Glen Edith, and Horn Valley !.

HELIPTERUM PTEROCHÆTUM, *Bentham.* Hermannsburg (Kempe); Bagot's Creek, by Mount Francis, Glen Helen, and Mount Squire !.

HELICHRYSUM AYERSII, *F. v. M.* Limestone rubble, east end of G. Gill Range, Hope Valley !, Ooraminna Pass !, Alice Springs (C. Giles), Finke River (Kempe); also Mount Olga (Gosse), Everard Range, S.A., and near Mount Squires, Cavenagh Range, W.A. (Elder Exped.). [The specimens obtained by the Horn Expedition are somewhat aberrant as regards the pappus of the exterior flowers, which is more rigid, with the bristlets connate towards the base into bundles, the numbers in the sets varying from few to several. The plant reaches the height of 1½ft. It reminds in some respects of Ixiolæna and Podolepis.—F. v. M.].

HELICHRYSUM CASSINIANUM, *Gaud.* River Finke (Stuart), McDonnell Range (E. Giles), Hermannsburg (Kempe); sandy ground, Ilpilla and Ooraminna Pass !.

HELICHRYSUM LAWRENCELLA, *F. v. M.* Shady and moist places, Hermannsburg (Kempe); Ooraminna Pass !.

HELICHRYSUM LUCIDUM, *Henckel.* Glen of Palms (E. Giles); Missionary Plain ! and Hermannsburg (Kempe); Chamber's Pillar and Reedy Creek !.

* HELICHRYSUM AMBIGUUM, *Turcz.* Young foliage viscid; rocky ground at Ilpilla Gorge, Mount Francis, Finke Gorge, Palm Creek and Mount Gillen !.

VAR. *semicalvum.* McDonnell Range (Stuart); sandhills, Idracowra, also Crown Point and River Stevenson !.

HELICHRYSUM APICULATUM, *Turcz.* Throughout the region on sandy soil !. Hermannsburg (Kempe).

* HELICHRYSUM THOMSONI, *F. v. M.* McDonnell Range (E. Giles); shaded rocks, Krichauff Range (Kempe), Tempe Downs, Bagot's Creek Gorge, Redbank Gorge, Stuart's Pass, and Simpson's Gap near Alice Springs. Before expansion of the inflorescence the subwoody stem is about six inches high. Extends to Mount Olga (E. Giles).

* HELICHRYSUM KEMPEI, *F. v. M.* Crevices of rock-faces, Krichauff Range (Kempe), Brinkley Bluff and Heavitree Gap !.

RUTIDOSIS HELICHRYSOIDES, *De Cand.* Hermannsburg (Kempe); sandy soil, south side of G. Gill Range, valley of the Darwent River and Lower Hugh River !.

MILLOTIA KEMPEI, *F. v. M.* Sandhills, Hermannsburg (Kempe).

MYRIOCEPHALUS STUARTII, *Bentham.* Hermannsburg (Kempe); Carmichael Creek !.

ANGIANTHUS PUSILLUS, *Bentham.* Bagot's Creek Gorge !.

GNEPHOSIS CYATHOPAPPA, *Bentham.* Burt Plain and plain north of Ooraminna Range !.

ERIOCHLAMYS KNAPPII, *F. v. M.* Hermannsburg (Kempe).

CALOCEPHALUS PLATYCEPHALUS, *Bentham.* McDonnell Range (E. Giles); Henbury, Darwent River Valley, Glen Helen, Upper Finke Valley near Mount Sonder !; also at the Goyder River !

‖ SIEGESBECKIA ORIENTALIS, *Linné.* Hermannsburg (Kempe), Stokes Pass, Finke Gorge and Stuart's Pass !.

WEDELIA VERBESINOIDES, *F. v. M.* Finke River (Stuart).

* WEDELIA STIRLINGII, *Tate*, n. sp. Rocky and stony ground, Stokes Pass, slopes of Mereenie Bluff, Mount Francis and Mount Sonder, Finke Gorge and Stuart's Pass !.

|| BIDENS BIPINNATUS, *Linné.* Hermannsburg (Kempe), Mount Sonder (Tietkens).

|| GLOSSOGYNE TENUIFOLIA, *Cassini.* Hermannsburg (Kempe), Mount Sonder (Tietkens); River Finke between Henbury and Parke's Gap, Glen Helen, Stuart's Pass !; Alice Springs (F. J. Gillen !).

|| CENTIPEDA ORBICULARIS, *Loureiro.* Mount Sonder (Tietkens); by the Finke River at Henbury and by Mount Sonder !.

CENTIPEDA THESPIDIOIDES, *F. v. M.* Finke River (Stuart), by Mount Sonder !.

SENECIO GREGORII, *F. v. M.* Finke River (Stuart), McDonnell Range (E. Giles), Mount Sonder (Tietkens), Hermannsburg (Kempe), Carmichael Creek, and not uncommon throughout the region !.

SENECIO MAGNIFICUS, *F. v. M.* Hermannsburg (Kempe), Carmichael Creek, Horn Valley, and generally on rich alluvial flats !.

· SENECIO LAUTUS, *Solander.* Illamurta, Tempe Downs, and banks of Upper Finke by Mount Sonder !.

SENECIO ODORATUS, *Hornemann.* Hermannsburg (Kempe), also sandhills by River Stevenson !.

SENECIO CUNNINGHAMII, *De Cand.* By junction of Palmer and Finke Rivers !.

ERECHTITES PICRIDIOIDES, *Turcz.* Moist sand of river beds, by Hermannsburg (Kempe).

ERECHTITES LACERATA, *F. v. M.* Glen Farewell (Tietkens); by moist river banks as at Bagot's and Reedy Creeks, Upper Finke by Mount Sonder, Alice Springs !.

The occurrence of SONCHUS ARVENSIS along the Finke towards its source was noted by E. Giles as early as 1872; it may have originated from the visits of Stuart in 1860-1862, if so it has spread since then, as it was observed very frequently along that river from Crown Point to Mount Sonder.

CAMPANULACEÆ.

* ISOTOMA PETRÆA, *F. v. M.* James Range and Hugh River (Stuart), McDonnell Range (E. Giles), Hermannsburg (Kempe), Glen Edith (Tietkens); shaded rocks, Tempe Downs, George Gill Range, Mount Tate, Finke Gorge, Stuart's Pass, Alice Springs !.

‖ WAHLENBERGIA GRACILIS, *A. de Cand.* Hermannsburg (Kempe); widely distributed, plains and valleys !.

CANDOLLEACEÆ.

CANDOLLEA FLORIBUNDA, *F. v. M.* McDonnell Range (E. Giles), loam flat by Conlin's Lagoon near Alice Springs !.

GOODENIACEÆ.

BRUNONIA AUSTRALIS, *Smith.* McDonnell Range (E. Giles); sandy ground, Hermannsburg (Kempe), Running Water, Chambers Pillar, and between Ooraminna and James Ranges !; Alice Springs (F. J. Gillen !).

LESCHENAULTIA DIVARICATA, *F. v. M.* Wide spread, Hermannsburg (Kempe). Sandhills by the Lower Hugh and south to Charlotte Waters !.

CATOSPERMA MUELLERI, *Bentham.* Near McDonnell Range (Dittrich). Sand plain stretching from south-west slope of Mount Tate !. Extending south to between the Alberga and Mount Olga (E. Giles).

SCÆVOLA SPINESCENS, *R. Brown.* Off Penny's Creek in George Gill Range. Common from Engoordina to Charlotte Waters !.

SCÆVOLA PARVIFOLIA, *F. v. M.* Alice Springs (C. Giles), Hermannsburg (Kempe); Idracowra, Illamurta and Mereenie Bluff !.

SCÆVOLA DEPAUPERATA, *R. Brown.* McDonnell Range (E. Giles), Hermannsburg (Kempe). Sandhills and plains, Idracowra, Chambers Pillar, Laurie's Creek, between Glen Edith and Carmichael Creek, valley of the Lower Hugh River and thence to Charlotte Waters !.

* SCÆVOLA OVALIFOLIA, *R. Brown.* Glen of Palms (E. Giles), Alice Springs (C. Giles), slopes of and on ! Mount Sonder (Tietkens); rocky ground at Mount Francis and in Stuart's Pass !.

*GOODENIA RAMELII, *F. v. M.* Stony or rocky ground, Krichauff Range (Kempe), Bagot's Creek Gorge, Mount Tate, Mount Francis, Glen Helen, Mount Sonder and Mount Gillen !.

GOODENIA HIRSUTA, *F. v. M.* Central Australia (Stuart).

*GOODENIA VILMORINIÆ, *F. v. M.* Hermannsburg (Kempe). Stony ground, Mereenie Bluff and Mount Francis !.

GOODENIA NICHOLSONI, *F. v. M.* North-west interior (Stuart).

GOODENIA GRANDIFLORA, *Sims.* Dashwood Creek (Tietkens).

*GOODENIA HORNIANA, *Tate*, n.sp. Growing in rock crevices, south escarpement of George Gill Range at Ready and Penny's Creek, Stuart's Pass !

GOODENIA STRANGFORDII, *F. v. M.* Hermannsburg (Kempe).

GOODENIA MUECKEANA, *F. v. M.* Between Mount Udor and George Gill Range (E. Giles); sandhills, Hermannsburg (Kempe); Tempe Downs (Thornton).

GOODENIA LARAPINTA, *Tate*, n. sp. Reedy Creek, sand plain north-east of Glen Edith, slope of Mereenie Bluff, and at Glen Helen !

GOODENIA HETEROCHILA, *F. v. M.* Alice Springs, softly hirsute, and Eagle Plain, a narrow-leaved variety !.

GOODENIA MITCHELLII, *Bentham.* Alice Springs and Charlotte Waters (C. Giles).

GOODENIA SEPALOSA, *F. v. M.* Hermannsburg (Kempe)

GOODENIA CYCLOPTERA, *R Brown.* Hermannsburg (Kempe); Gosse Range (J. Schmidt). Sandy ground by Running Waters, thence extending south to River Stevenson, etc. !.

GOODENIA SUBINTEGRA, *F. v. M.* Finke River (R. Warburton); Gosse Range (Schwartz); Running Waters !; Alice Springs (F. J. Gillen !); also Charlotte Waters (C. Giles).

GOODENIA MICROPTERA. *F. v. M.* Alice Springs and Charlotte Waters (C. Giles).

VELLEYA CONNATA, *F. v. M.* McDonnell Range (E. Giles); Hermannsburg (Kempe); Laura Vale and Warman Rocks (Tietkens); Alice Springs (F. J. Gillen !).

GENTIANEÆ.

ERYTHRÆA SPICATA, *Persoon.* McDonnell Range (E. Giles); sand of river-beds, Hermannsburg (Kempe); Conlin's Lagoon near Alice Springs !.

PLANTAGINEÆ.

PLANTAGO VARIA, *R. Brown.* Upper Finke by Mount Sonder and Ooraminna Pass !

PRIMULACEÆ.

SAMOLUS REPENS, *Persoon.* Hermannsburg (Kempe); Illamurta Soakage; River Walker at Tempe Downs; River Finke at Finke Gorge, and Palm Creek !.

JASMINEÆ.

JASMINUM LINEARE, *R. Brown.* McDonnell and Gosse Ranges (E. Giles); Hermannsburg (Kempe); Bond Spring and Mount Sonder (Tietkens). South side of George Gill Range !.

JASMINUM CALCAREUM, *F. v. M.* McDonnell Range (E. Giles); Krichauff Range (Kempe), Mount Sonder (Tietkens); Tempe Downs, edge of plain on south side of George Gill Range, by the Upper Finke and at Stuart's Pass !.

APOCYNEÆ.

CARISSA BROWNII, *F. v. M., var. lanceolata.* Glen of Palms (Kempe). In rocky channel of River Darwent, Mount Francis, Glen Helen, Horn Valley and Burt Plain !.

ASCLEPIADEÆ.

CYNANCHUM FLORIBUNDUM, *R. Brown.* Beds of creeks, Hermannsburg (Kempe), Emily Gap, Glen Helen and Watson Hills (Tietkens); Upper Finke and tributaries by Mount Sonder !; also at Crown Point and Goyder River !.

SARCOSTEMMA AUSTRALE, *R. Brown.* Hermannsburg (Kempe); Bagot's Creek Gorge, by the Hugh, on north side of Brinkley Bluff and at Painta Spring !.

DÆMIA KEMPEANA, *F. v. M.* Hermannsburg (Kempe); Mount Sonder, Laura Vale and Warman Rocks (Tietkens); sand plain off Bagot's Creek !. Extends to Fraser Range, West Australia (Elder Exped.).

MARSDENIA LEICHHARDTIANA, *F. v. M.* McDonnell Range (E. Giles), Hermannsburg (Kempe), Mereenie Bluff (Tietkens), Burt Plain !.

CONVOLVULACEÆ.

IPOMŒA MUELLERI, *Bentham.* McDonnell Range (E. Giles), Bond Spring, Mount Sonder ! and Glen Helen ! (Tietkens); Bagot's Creek, Reedy Creek Gorge, between River Todd and Ooraminna, at Deep Well in James Range !. Also abundant by waterholes from Engoordina to River Stevenson !.

IPOMŒA RACEMIGERA, *F. v. M.* and *Tate.* Glen Helen (Tietkens) Sandy channel of the River Hugh in Stuart's Pass !. Fruit, hitherto unknown, slightly exceeding calyx, ovoid conic in vertical outline, roundly quadrangular in transverse outline, longitudinally fine-striated, splitting into four valves, two-celled, one seed in the whole capsule, seed clothed with short appressed hairs.

CONVOLVULUS ERUBESCENS, *Sims.* McDonnell Range (E. Giles), Hermannsburg (Kempe); wide spread over the low level tracts !.

POLYMERIA LONGIFOLIA, *Lindley.* Hermannsburg (Kempe).

POLYMERIA ANGUSTA, *Lindley.* Hermannsburg (Kempe).

BREWERIA ROSEA, *F. v. M.* McDonnell Range and Glen of Palms (E. Giles), Hermannsburg (Kempe).

| EVOLVULUS LINIFOLIUS, *Linné.* Brinkley Bluff (Stuart), McDonnell Range (E. Giles), Krichauff Range (Kempe), Glen Helen (Tietkens), Alice Springs, Ilpilla, sand plain off Bagot's Creek, alluvial flats on Carmichael Creek, Mereenie Bluff !.

| CUSCUTA AUSTRALIS, *R. Brown.* Hermannsburg (Kempe). On young plants of *Cassia phyllodinea* at the Walker and Palmer Rivers junction !; Alice Springs (F. J. Gillen !), on *Boerhaavia diffusa.* Also Charlotte Waters (C. Giles).

SOLANACEÆ.

SOLANUM FEROCISSIMUM, *Lindley.* McDonnell Range (E. Giles); Hermannsburg (Kempe); Bond Spring and Laura Vale (Tietkens); Glen Helen !.

* SOLANUM ORBICULATUM, *Dunal.* Mount Sonder (Tietkens).

SOLANUM ESURIALE, *Lindley.* McDonnell Range (E. Giles). Sandy soil Hermannsburg (Kempe); south side of George Gill Range, Illara Water and Glen Helen !.

SOLANUM STURTIANUM, *F. v. M.* Rocks near Hermannsburg (Kempe) and Tempe Downs !.

SOLANUM EREMOPHILUM, *F. v. M.* Reedy Creek Gorge; slopes of Mount Sonder !.

*SOLANUM PETROPHILUM, *F. v. M.* Bagot's Creek Gorge, Stuart's Pass and on Mount Gillen !.

SOLANUM ELLIPTICUM, *R. Brown.* On rich clay soil, also in the ranges, Finke River (Kempe); Mount Sonder ! (Tietkens). Rocks at Tempe Downs, Ilpilla Gorge, Mount Tate, Mereenie Bluff, Mount Francis and Mount Sonder !.

DATURA LEICHHARDTII, *F. v. M.* By margins of all creeks, particularly the Upper Finke and its tributaries !; Glen of Palms (E. Giles) and Hermannsburg (Kempe); Mount Sonder ! (Tietkens).

NICOTIANA SUAVEOLENS, *Lehmann.* By margins of nearly all creeks from south of Charlotte Waters to the Upper Finke !; Glen of Palms (E. Giles) and Hermannsburg (Kempe).

DUBOISIA HOPWOODI, *F. v. M.* Near Mount Liebig (E. Giles), Hermannsburg (Kempe), Glen Edith (Tietkens). Ilpilla and sand plain north-east from Glen Edith !; on sand-hills between George Gill Range and Ayers Rock (Spencer !).

SCROPHULARINÆ.

‖ MIMULUS GRACILIS, *R. Brown.* Carmichael Creek !.

‖ STEMODIA VISCOSA, *Roxburgh.* Mount Sonder ! (Tietkens). By river channels and water courses, between Engoordina and Sullivan's Creek, at the Finke-Palmer Junction, Tempe Downs, by Belt Range, Glen Helen, Stuart's Pass, Alice Springs, Lower Hugh River, and south to Lilla Creek and Goyder River !.

STEMODIA MORGANIA, *F. v. M.* Hermannsburg (Kempe). Also VAR. *parviflora*, at the River Finke by Mount Humphries and at the Goyder River !.

‖ LIMOSELLA AQUATICA, *Linné.* Bagot's and Laurie's Creeks, Upper Finke and tributaries by Mount Sonder, Stuart's Pass and Conlin's Lagoon !.

* BUECHNERA LINEARIS, *R. Brown.* Near Mount Sonder (Tietkens); bed of south ravine of Mount Tate !.

ELACHOLOMA HORNI, *F. v. M.* and *Tate* (gen. et spec. nov.).* Wet claybanks, Carmichael Creek at its junction with Deering Creek !.

* The authors regret that they cannot honour the patron of the Expedition as they would have wished, because the generic name *Hornia* is already preoccupied in botanical nomenclature.

BIGNONIACEÆ.

* TECOMA AUSTRALIS, *R. Brown.* McDonnell Range (Stuart); Mount Sonder and Gill's Creek (Tietkens). Growing on rocky declivities, Krichauff Range (Kempe), Tempe Downs, Ilpilla Gorge, gorges of George Gill Range, Mount Tate, Redbank Gorge and Stuart's Pass. Extends to Everard and Barrow Ranges (Elder Exped.).

ACANTHACEÆ.

* RUELLIA PRIMULACEA, *F. v. M.* McDonnell Range (E. Giles), Alice Springs (C. Giles). On rocks at Parke's Gap, Illamurta and Horn Valley !.

| JUSTICIA PROCUMBENS, *Linné.* Hermannsburg (Kempe); Mount Sonder and Ooraminna (Tietkens). Common in the low level tracts !.

* JUSTICIA KEMPEANA, *F. v. M.* A dense shrub spreading from two to three feet diameter; leaves cuneate-oval, dentate on the margin; flowers pink; exclusively confined to stony ground or rock-slopes. Hermannsburg (Kempe), Ilpilla Gorge, Horn Valley, declivities between Harris Creek and River Hugh, Ooraminna Pass !.

LABIATÆ.

* PLECTRANTHUS PARVIFLORUS, *Henckel.* Mount Sonder (Tietkens). Shaded rocks, Illara Water, Reedy Creek and Palm Creek !. Extends to Everard Range (Elder Exped.).

* PROSTANTHERA SCHULTZII, *F. v. M.*, m.s., Cens., p. 169 (1889). "Differs from *P. rotundifolia*, R. Br., in smaller, less crenate and thicker leaves," *F. v. M.* in *litteris*. Flowers and fruit remain unknown. Higher slopes of Mount Sonder !.

* PROSTANTHERA WILKIEANA, *F. v. M.* "Sandstone Rocks" and Mount Sonder ! (Tietkens). Rocky declivities, Tempe Downs and George Gill Range !. Extends to Everard Range (Elder Exped.), and between Mount Olga and Barrow Range (E. Giles).

PROSTANTHERA BAXTERI, *Cunn.* Shady places in Krichauff Range (Kempe); Running Water !.

PROSTANTHERA STRIATIFLORA, *F. v. M.* Gosse and McDonnell Ranges (E. Giles), Mount Sonder !, and Glen Edith (Tietkens). Rich plains, Hermannsburg (Kempe), Running Water, east end of George Gill Range, Bagot's Creek Gorge, by Belt Range, Alice Springs !.

TEUCRIUM RACEMOSUM, *R. Brown.* Mount Sonder (Tietkens), Finke River (E. Giles).

TEUCRIUM GRANDIUSCULUM, *F. v. M.* and *Tate.* Watson Hills and Gill's Creek (Tietkens).

VERBENACEÆ.

SPARTOTHAMNUS TEUCRIIFLORUS, *F. v. M.* Hermannsburg (Kempe); Bond Spring and Glen Helen (Tietkens). In shade of trees, south side of George Gill Range !.

*SPARTOTHAMNUS PUBERULUS, *F. v. M.* Base of escarpment at Heavitree Gap ! Foliage and stem stellately downy; leaves lanceolate, attenuate at the base but sessile; flowers not seen, fruit coral red.

VERBENA MACROSTACHYA, *F. v. M.* Beds of creeks, Hermannsburg (Kempe), by the Finke near Mount Sonder and by the Hugh at Alice Well !; also Crown Point and Stevenson River !.

NEWCASTLIA SPODIOTRICHA, *F. v. M.* McDonnell Range (E. Giles); sandhills, Hermannsburg (Kempe).

NEWCASTLIA BRACTEOSA, *F. v. M.* Gill and McDonnell Ranges, also between Mount Olga and Warburton Range (E. Giles).

DICRASTYLIS DORANII, *F. v. M.* Hermannsburg (Kempe). Sandhills and plains; Eagle Plain by Palmer River, Reedy Creek, between Glen Edith and Carmichael Creek, Ooraminna Pass, Deep Well, and thence south to between Boggy Flat and Charlotte Waters !, Stony ground, slopes of Mounts Tate and Sonder, Stuart's Pass !. Flowers blue.

DICRASTYLIS OCHROTRICHA, *F. v. M.* Laura Vale (Tietkens), Ilpilla Gorge, Bagot's Creek and Mount Sonder !. Extends to Barrow Range (E. Giles), and Victoria Desert (Elder Exped.).

DICRASTYLIS GILESII, *F. v. M.* Glen of Palms (E. Giles); also Mounts Olga (E. Giles) and Conner (Tietkens).

DICRASTYLIS BEVERIDGEI, *F. v. M.* Between Mount Udor and George Gill Range; also Mount Olga (E. Giles).

DICRASTYLES LEWELLINI, *F. v. M.* McDonnell Range (E. Giles). Sandhills (Kempe), Missionary Plain !.

CLERODENDRON FLORIBUNDUM, *R. Brown.* Hermannsburg (Kempe); Laura Vale and Watson Hills (Tietkens). Sandhills between Laurie's Creek and Glen Edith. Source of Darwent River, Mount Francis, Mount Sonder, Horn Valley !.

MYOPORINÆ.

* EREMOPHILA STRONGYLOPHYLLA, *F. v. M.* Throughout George Gill Range !.

EREMOPHILA MITCHELLI, *Bentham.* Hermannsburg (Kempe). Sandhills and plains; Bagot's Creek, Hope Valley, Glen Edith to Carmichael Creek, Ooraminna Pass and thence to Charlotte Waters !.

EREMOPHILA PAISLEYI, *F. v. M.* Sandhills at Idracowra and between James Range and Alice Creek !; also west end of Lake Amadeus and south-west of Erldunda (Tietkens).

EREMOPHILA STURTII, *R. Brown.* McDonnell Range (E. Giles); Hermannsburg (Kempe); Idracowra !.

EREMOPHILA CLARKEI, *F. v. M.* Warman Rocks (Tietkens), Ilpilla, Reedy Creek, Mereenie Bluff and scrub south-west of, Glen Helen, Ooraminna Pass !.

EREMOPHILA GILESII, *F. v. M.* McDonnell Range (E. Giles); Warman Rocks (Tietkens). Illamurta !.

EREMOPHILA LATROBEI, *F. v. M.* McDonnell Range (E. Giles); Hermannsburg (Kempe), Laura Vale and Warman Rocks (Tietkens). Ilamurta and south side of George Gill Range !.

VAR. (= *Tietkensi, F. v. M.* and *Tate*). Mount Sonder and Laura Vale (Tietkens), Ilpilla Gorge and south side of George Gill Range !.

EREMOPHILA LONGIFOLIA, *F. v. M.* McDonnell and Gosse Ranges (E. Giles). Sand plain off George Gill Range, valley of Carmichael Creek, foot slopes of Mount Sonder and elsewhere !.

EREMOPHILA FREELINGII, *F. v. M.* Hermannsburg (Kempe). Common on stony ground from the southward to Chandler Range; frequent on the tablelands —as at Illamurta, Tempe Downs, George Gill Range, etc. !.

EREMOPHILA MACDONNELLI, *F. v. M.* Hermannsburg ! (Kempe). Common, on sandy ground from the southward to the junction of the Finke and Palmer Rivers; valley of Alice Creek !.

*EREMOPHILA GOODWINII, *F. v. M.* Glen of Palms and McDonnell Range (E. Giles). Rocks and rocky ground, Parke's Gap, Ilpilla, slopes of Mount Tate, Horn Valley, Finke Gorge, Stuart's Pass !.

EREMOPHILA WILLSII, *F. v. M.* Finke River (Stuart), Hermannsburg (Kempe), Chambers Pillar !, etc.

EREMOPHILA PLATYCALYX, *F. v. M.* North-west interior of South Australia (Stuart).

EREMOPHILA BROWNII, *F. v. M.* McDonnell Range (Stuart), Missionary Plain !, near Hermannsburg (Kempe), Alice Creek !.

EREMOPHILA DUTTONII, *F. v. M.* From Sullivan's Creek to Idracowra; Ilpilla, Tempe Downs, Heavitree Gap (with yellow flowers), Ooraminna and south to Alice Creek !.

EREMOPHILA MACULATA, *F. v. M.* North of Mount Harris (Tietkens), Eagle Plain by Palmer River !.

EREMOPHILA CHRISTOPHORI, *F. v. M.* River Hugh (C. Giles); foothills of Mount Sonder !.

MYOPORUM DAMPIERI, *Cunn.* Glens of Palms (E. Giles), Hermannsburg (Kempe). River Finke at Running Water; Tempe Downs; Goyder Pass, Finke Gorge !. Drupes red.

ASPERIFOLIÆ.

*CYNOGLOSSUM DRUMMONDII, *Bentham.* Hermannsburg (Kempe). Rock-slopes, Illamurta, Stokes Pass, Horn Valley and Finke Gorge !.

‖ POLLICHIA ZEYLANICA, *F. v M.* Mostly on stony ground, and ascending to high elevations on the tablelands and other eminences throughout the Larapintine area ! (recorded by E. Giles, Kempe and Tietkens). In the region to the south it occurs more frequently on the sandhills !.

HALGANIA CYANEA, *Lindley.* Brinkley Bluff (Stuart), McDonnell Range (E Giles). Ranges and sandhills by Hermannsburg (Kempe). Slopes of Mounts Tate, Sonder and Gillen, Stuart's Pass, Alice Springs. Sandhills, valley of the Lower Hugh River and thence to Charlotte Waters !.

HALGANIA INTEGERRIMA, *Endl.* Mount Harris (Tietkens).

HELIOTROPIUM PLEIOPTERUM, *F. v. M.* Sandhills by Hermannsburg (Kempe), Idracowra and Chambers Pillar; junction of Palmer and Finke Rivers; Alice Creek, the Lower Hugh River and thence to Engoordina !.

|| HELIOTROPIUM CURASSAVICUM, *Linné.* Margin of the Finke River in the Finke Gorge !, at Hermannsburg (Kempe), and also at Crown Point !.

| HELIOTROPIUM UNDULATUM, *Vahl.* Hermannsburg (Kempe). Between Henbury and Parke's Gap, Redbank Gorge, Mount Francis !.

HELIOTROPIUM ASPERRIMUM, *R. Brown.* McDonnell Range (E. Giles), Hermannsburg (Kempe), Laura Vale (Tietkens); also Crown Point and at the Goyder River !.

HELIOTROPIUM OVALIFOLIUM, *Forskael.* Slopes of Mereenie Bluff !; also at Lake Macdonald (Tietkens).

HELIOTROPIUM FILAGINOIDES, *Bentham.* Lake Macdonald (Tietkens). Near Charlotte Waters (E. Giles).

HELIOTROPIUM PANICULATUM, *R. Brown.* Mount Sonder ! and Painta Spring (Tietkens). Mount Francis and Stuart's Pass !. Common on sandy alluvium from the Goyder River to Macumba.

EPACRIDEÆ.

* STYPHELIA MITCHELLII, *F. v. M.* At high elevations on Mount Sonder !.

PEDALINEÆ.

JOSEPHINA EUGENIÆ, *F. v. M.* Watson Hills (Tietkens). Also sandhills by the River Stevenson near Macumba !.

CONIFERÆ.

* CALLITRIS VERRUCOSA, *R. Brown.* Strictly saxatile in habitat, and always of the smooth-coned variety. Chandler's Range (the most southern station observed), thence widely spread to the western and northern confines of the Larapintine region !. Recorded by E. Giles and Kempe.

CYCADEÆ.

* ENCEPHALARTOS MACDONNELLI, *F. v. M.* Brinkley Bluff (Stuart), Stuart's Pass, and in the bed of the Hugh north of Paisley Bluff !. Penny Springs ! in

George Gill Range (E. Giles). Krichauff Range (Kempe) and Palm Creek off Glen of Palms !. Mount Sonder and Heavitree Gap !. Always gregarious and saxatile.

Macrozamia Macdonnelli was the name given to a cycad, collected by Stuart in Central Australia, by F. v. M. in Frag. Phyt. Aust., vol. ii., p. 179, and attributed to the locality, River Neale. Stuart in his "Journals of Explorations" makes no reference to the plant as from there, but at p. 157 (2nd edit.), he describes a cycad calling it a palm tree, which leaves no doubt that the original specimens came from Brinkley Bluff, where I have actual knowledge of its occurrence. Moreover, F. v. M. in the "Enumeration of the Plants," p. 505, *op. cit.*, states that "a cycadeous plant occurs on McDonnell Range," and makes no allusion to the River Neale, which is several hundreds of miles south of the most southerly station actually known. By this correction the species is restricted to the George Gill, Krichauff and McDonnell Ranges.

Stems attain to four feet high with a diameter of eighteen inches, the longer leaves measure ten feet in length, the petioles trigonal and concave above, and bear from ninety to one hundred pairs of leaflets. The leaflets are flat, margin entire, the larger ones about one foot long and one-quarter inch wide, the lower leaflets gradually shortened, but none reduced to spines, the basal eighteen inches of the petiole without leaflets, attenuated to a slight pungent point, the upper surface obscurely seven- to nine-veined, and the interstitial spaces with distant granulose streaks ; the base of the leaflet with a relatively large articular callosity, suddenly contracted above, the insertion marginal and axial.

Male cones ellipsoid-cylindrical, twelve inches long by three and a quarter inches wide ; antheriferous scales very numerous and thick, the lower ones blunt and abbreviated, those towards the middle short-pointed, those towards the summit with vertically ascendent apices, the longest of which is three-quarters of an inch and the attenuated point is somewhat pungent. This species was associated by Mr. Bentham, Fl. Austral., vol. vi., p. 253, with *E. Fraseri*, but it differs from it and therefore from *E. spiralis* by the rachis not being raised between the pinnæ. The male cones of *E. Macdonnelli*, hitherto undescribed, are equally large as those of *E. Fraseri ;* but its upper scales have not the long subulose tips of that species.

HYDROCHARIDEÆ.

Ottelia ovalifolia, *L. C. Richard.* Rock pool in Reedy Creek Gorge, George Gill Range !. All the plants exhibit an extreme of dimorphism, which

was pointed out as pertaining to this species by F. v. M. in "Key to the Victorian Plants," i., p. 422, and more fully dealt with in the "Gardener's Chronicle." In the Reedy Creek plants, the perianth is almost obliterated and uncoloured, and the spathe always remain perfectly closed.

AMARYLLIDEÆ.

CRINUM FLACCIDUM, *Herbert.* Latitude 32° to 22° (Stuart). Near McDonnell Range as *C. angustifolium* (teste F. v. M.). Common in the valley of the Stevenson River !.

LILIACEÆ.

WURMBSEA DIOICA, *F. v. M.* Glen Edith, etc. (Tietkens).

THYSANOTUS EXILIFLORUS, *F. v. M.* McDonnell Range (E. Giles); sandhills, Hermannsburg (Kempe).

CORYNOTHECA LATERIFLORA, *F. v. M.* Sandhills, Hermannsburg (Kempe).

* XEROTES DURA, *F. v. M.* In rocky clefts, Ilpilla Gorge and Palm Creek !.

XEROTES LEUCOCEPHALA, *R. Brown.* Sand plain by the Finke, Hermannsburg ! (Kempe), Gill's Creek and Laura Vale (Tietkens), Walker River valley near Palmer Junction !.

XANTHORRHŒA THORNTONI, *Tate*, n. sp. Sandhills, Eagle Plain; between Laurie's Creek and Glen Edith !, as observed by Gosse; Rudall's Creek (E. Giles). Missionary Plain one mile north of Pine Point, and south side of valley of Carmichael Creek !.

PALMÆ.

* LIVISTONA MARIÆ, *F. v. M.* Glen of Palms (E. Giles), along the Finke River and some of its tributaries in Krichauff Range (Kempe). The principal colony of this stately palm, which attains to a height of ninety feet, is in Palm Creek, which joins the Finke at about nine miles south from Hermannsburg; the trees, rooting in the joints of the bare sandstone floor of the creek-bed, extend for a length of about two miles, commencing at about three miles from its junction with Glen of Palms, altogether there cannot be more than about a hundred full-grown individuals; the tributary-branches of Palm Creek have a few individual trees but not extending beyond one-fourth mile from the main creek. From Palm Creek a few individuals occur along the Finke Channel as far as Boggy Water in the Glen of Palms.

This species has been recorded as inhabiting a very circumscribed area in the valley of the Fortescue River (F. v. M., in "Plants of N.W. Australia," Perth, 1881, p. 12), but further material has proved that the fan-palm of West Australia is distinct and it has been named *L. Alfredi* (F. v. M. in Victorian Naturalist, December, 1892).

TYPHACEÆ.

TYPHA ANGUSTIFOLIA, *Linné.* Hermannsburg (Kempe); Illara Water, Tempe Downs, Bagot's and Reedy Creeks, Palm Creek !.

FLUVIALES.

NAIAS MAJOR, *Allioni.* River Finke at Running Water, Palm Creek ! near Hermannsburg (Kempe); Illara Water, Bagot's Creek !.

POTAMOGETON TEPPERI, *A. Bennett.* Finke River at Henbury and Running Water; Reedy Creek; Palm Creek off Glen of Palms !.

TRIGLOCHIN CALCITRAPA, *Hooker.* Palm Creek, Carmichael Creek !; also by the Stevenson River !.

TRIGLOCHIN MUCRONATA, *R. Brown.* Clay-banks of Finke River at Henbury !.

COMMELINEÆ.

* COMMELINA ENSIFOLIA, *R. Brown.* McDonnell Range (Stuart); Glen Helen (Tietkens). Shady places, Hermannsburg (Kempe). Alice Springs (F. J. Gillen !).

JUNCACEÆ.

JUNCUS PALLIDUS, *R. Brown.* Illara Water; Bagot's, Reedy and Penny Creeks in George Gill Range; River Finke by Mount Sonder !.

ERIOCAULEÆ.

ERIOCAULON GRAPHITINUM, *F. v. M.* and *Tate.* West end of McDonnell Range (Tietkens).

RESTIACEÆ.

CENTROLEPIS POLYGYNA, *Hier.* Palm Creek and Conlin's Lagoon !.

CYPERACEÆ.

Cyperus squarrosus, *Linné.* Henbury, Bagot's Creek, Carmichael Creek, Upper Finke by Mount Sonder and Palm Creek !.

Cyperus difformis, *Linné.* Glen Helen ! (Tietkens), Henbury and Carmichael Creek !.

Cyperus vaginatus, *R. Brown.* McDonnell Range as *C. textilis* (E. Giles), Hermannsburg (Kempe), Alice Springs (C. Giles).

Cyperus fulvus, *R. Brown.* Glen Helen (Tietkens), Reedy Creek, Engoordina !.

Cyperus rotundus, *Linné.* Charlotte Waters and Alice Springs ! (C. Giles). Loam-flats of the River Finke at Crown Point, Henbury, etc !.

Cyperus subulatus, *R. Brown.* Alice Springs (C. Giles).

* Cyperus umbellatus, *Bentham*, fl., Hongk., 386, on rocky slopes of Mount Tate and in Stuart's Pass !.

[The Central Australian plant can be distinguished from the typic form as var. *fasciculigerus*, inasmuch as the spikes are shortened almost all to fascicles with a tendency to ramification. But similar variations may be observed in some other species of Cyperus, for instance our *C. lucidus.* The plant before us has the radical and floral leaves also narrower than usual, which is doubtless from the effect of desert clime. F. v. M] The whole plant is very viscid.

Heleocharis acuta, *R. Brown.* Carmichael Creek ! ; also at Opossum Waterhole, River Stevenson !.

Heleocharis capitata, *R. Brown.* Palm Creek !.

Fimbristylis acuminata, *Vahl.* West end of McDonnell Range (Tietkens).

Fimbristylis communis, *Kunth.* Gill's Creek (Tietkens). Sandy loam flats, widely spread !.

Fimbristylis ferruginea, *Vahl.* Finke Gorge (with minutely hoary pubescent glumes) !.

Fimbristylis barbata, *Bentham.* Between Alice Springs and Charlotte Waters (C. Giles).

Scirpus riparius, *Sprengel.* Conlin's Lagoon and Goyder Pass !.

|| SCIRPUS SUPINUS, *Linné.* Reedy and Carmichael Creeks !.

| SCIRPUS PUNGENS, *Vahl.* Illara Water and Palm Creek !.

| SCIRPUS LITORALIS, *Schrader.* Palm Creek !, Hermannsburg (Kempe), Illara Water !.

|| LIPOCARPHA MICROCEPHALA, *R. Brown.* Carmichael Creek and Stuart's Pass !.

| FUIRENA GLOMERATA, *Lamarck.* West end of McDonnell Range (Tietkens).

GRAMINEÆ.

|| ERIOCHLOA POLYSTACHYA, *H.* and *K.* Hermannsburg (Kempe). Engoordina and southward to the Macumba !.

PANICUM DIVARICATISSIMUM, *R. Brown.* Hermannsburg (Kempe); Running Water !.

|| PANICUM LEUCOPHŒUM, *H.* and *K.* Hermannsburg (Kempe). Running Water and common throughout the region !.

PANICUM ARGENTEUM, *R. Brown.* Near Hermannsburg (*fide* F. v. M.).

PANICUM GRACILE, *R. Brown.* East end of George Gill Range !.

PANICUM HELOPUS, *Trin.* Henbury, also Crown Point !.

PANICUM GILESII, *Bentham.* Hermannsburg (Kempe); also Charlotte Waters (C. Giles).

|| PANICUM DISTACHYON, *Linné.* Hermannsburg (Kempe).

PANICUM PAUCIFLORUM, *R. Brown.* In the interior (Stuart), near Alice Springs (C. Giles).

|| PANICUM DECOMPOSITUM, *R. Brown.* Hermannsburg (Kempe), Glen Helen (Tietkens), Bagot's Creek !.

| SETARIA MACROSTACHYA, *H.* and *K.* Hermannsburg (Kempe).

| SETARIA VIRIDIS, *Palisot.* McDonnell Range (Giles). By nearly all river banks in the region !.

PENNISETUM REFRACTUM, *F. v. M.* Alice Springs (Giles). Banks of the Finke at Idracowra and Crown Point !.

SPINIFEX PARADOXUS, *Bentham.* Alice Springs (Giles), Hermannsburg (Kempe); plain off George Gill Range, etc.!.

‖ PEROTIS RARA, *R. Brown.* Hermannsburg (Kempe); Ilpilla Creek and at Alice Springs !.

TRAGUS RACEMOSUS, *Haller.* McDonnell Range (E. Giles), Hermannsburg (Kempe). Ilpilla and throughout the region !.

* NEURACHNE ALOPECUROIDES, *R. Brown.* Stony slopes in the Ilpilla Gorge !.

IMPERATA ARUNDINACEA, *Cyrillo.* Hermannsburg (Kempe). Illamurta Soakage and Tempe Downs !.

ERIANTHUS FULVUS, *Kunth.* Bagot's Creek, and in ravine on south side of Mount Tate !.

ANDROPOGON ANNULATUS, *Forsk.* Reedy Creek in George Gill Range !.

ANDROPOGON SERICEUS, *R. Brown.* Hermannsburg (Kempe).

ANDROPOGON PERTUSUS, *Willd.* South side of George Gill Range, also at Crown Point !. Extends to Mount Olga (E. Giles).

ANDROPOGON EXALTATUS, *R. Brown.* Hermannsburg (Kempe); Ilpilla Gorge and Tempe Downs !.

* ANDROPOGON BOMBYCINUS, *R. Brown.* McDonnell Range (Stuart); Mount Zeil (Tietkens). Ilpilla Gorge, Tempe Downs, Mount Tate and Mount Francis !.

ANDROPOGON GRYLLUS, *Linné.* Alice Springs (C. Giles). Alluvial flats and river margins, Running Water, Ilpilla, Illara Water, Tempe Downs, Carmichael Creek, Upper Finke by Mount Sonder, Horn Valley, Alice Creek !.

‖ ANTHISTIRIA CILIATA, *Linné.* Hermannsburg (Kempe). Running Water, Tempe Downs, Mount Francis, etc., chiefly on rocky slopes !.

ANTHISTIRIA AVENACEA, *F. v. M.* Root-stock densely silky-hairy. Loamy plains and flats, south side of George Gill Range, Hope Valley, Glen Edith and Horn Valley !.

ARISTIDA STIPOIDES, *R. Brown.* Hermannsburg (Kempe), between Alice Springs and Charlotte Waters (C. Giles). Mulga scrub near source of Carmichael Creek !.

ARISTIDA ARENARIA, *Gaud.* Between Alice Springs and Charlotte Waters (C. Giles). Common throughout the region !.

ARISTIDA RAMOSA, *R. Brown.* Hermannsburg (Kempe).

ARISTIDA CALYCINA, *R. Brown.* Hermannsburg (Kempe); near Alice Springs (C. Giles), Glen Helen and Tempe Downs !.

STIPA SCABRA, *Lindley.* Edgar Spring, a tributary source of Harris Creek !.

PAPPOPHORUM COMMUNE, *F. v. M.* McDonnell Range (E. Giles); Ranges, Hermannsburg (Kempe). Not infrequent throughout the region !.

|| SPOROBOLUS INDICUS, *R. Brown.* Alice Springs (C. Giles).

SPOROBOLUS LINDLEYI, *Bentham.* Hermannsburg (Kempe); Glen Helen (Tietkens), Idracowra !.

SPOROBOLUS ACTINOCLADUS, *F. v. M.* Idracowra !.

ERIACHNE ARISTIDEA, *F. v. M.* Common on the Triodia sandhills and plains north and west of Engoordina, to the south side of George Gill Range and Ooraminna Pass, also south as far as Crown Point ! and Charlotte Waters (C. Giles).

* ERIACHNE SCLERANTHOIDES, *F. v. M.* McDonnell Range (E. Giles). Ilpilla Gorge, Tempe Downs, Mount Tate, Mount Gillen !.

DANTHONIA BIPARTITA, *F. v. M.* Between Ooraminna and James Ranges !.

ASTREBLA PECTINATA, *F. v. M.* Deep Well in James Range to Alice Creek. Also stony tablelands south from Charlotte Waters !.

CHLORIS ACICULARIS, *Lindley.* Alice Springs (C. Giles), Hermannsburg (Kempe). Also Crown Point, Charlotte Waters, and creek margins southward !

CHLORIS TRUNCATA, *R. Brown.* Hermannsburg (Kempe).

|| CHLORIS BARBATA, *Swartz.* Carmichael Creek and Alice Springs !; also River Stevenson (Stuart).

CHLORIS SCARIOSA, *F. v. M.* Glen Helen !.

|| ELEUSINE CRUCIATA, *Lamarck.* Hermannsburg (Kempe), and common throughout the region !.

ELEUSINE DIGITATA, *Sprengel.* McDonnell Range (E. Giles). Banks of the River Finke at Engoordina, and by Mount Musgrave in the Finke Gorge; also Adminga Creek !.

‖ DIPLACHNE LOLIIFORMIS, *F. v. M.* Between Alice Springs and Charlotte Waters (C. Giles), as at Mount Squire near Engoordina !.

‖ DIPLACHNE FUSCA, *Palisot.* River Finke at Finke Gorge and Henbury !, also River Stevenson !.

TRIODIA PUNGENS, *R. Brown.* The chief vegetation of the rocky tablelands and hill slopes.

TRIODIA IRRITANS, *R. Brown.* Ubiquitous (Kempe). Also sandhills as far north as Macumba !.

The porcupine grass was seen rarely in flower, and then always with the floral characters and viscid leaf-sheaths of *T. pungens*; if one may judge of the species by the presence or absence of a viscid exudation, then the ubiquitous species is *T. pungens* and not *T. irritans*; indeed I have not observed *T. irritans* as a saxatile species, if at all, even in the Larapintine region. Bentham in Fl. Aust., vol. vii., pp. 606 and 607, indicates *T. pungens* as a more northern species than *T. irritans*, whilst the latter is "probably the 'porcupine grasses' of the southern interior deserts of Australia;" my observations are in accord therewith, and I am afraid that Mr. Kempe's determination is in the main, at least, incorrect. The young leaves in life are flat and copiously covered with a varnish, which for its tenacious adhesiveness may be compared to copal varnish; on drying the leaves roll up into a cylinder, and with age the same thing happens concurrently with the disappearance of the viscid exudation from the surface of the leaves, though some may be retained on the less exposed leaf-sheaths.

TRIODIA SP. (? *T. Mitchelli*, Bentham). "Old-man porcupine." Forming exceedingly large tussocks, up to eight feet high and twelve feet diameter, foliage of a dull ashen grey; flowers not seen. Tempe Downs, Rudall Creek by Mereenie Bluff, under Mount Sonder !, Palmer River (Spencer).

‖ ERAGROSTIS TENELLA, *Palisot.* McDonnell Range and Charlotte Waters (C. Giles). Henbury, Running Water and Reedy Creek !; also Stevenson River ! (Stuart) and Giddea Creek near Oodnadatta !.

ERAGROSTIS TRICHOPHYLLA, *Bentham.* No locality (Tietkens).

ERAGROSTIS DIANDRA, *Steudel.* Glen Helen (Tietkens); Carmichael Creek !.

‖ ERAGROSTIS BROWNII, *Nees.* Hermannsburg (Kempe).

ERAGROSTIS SPECIOSA, *Steudel.* Running Water by banks of Finke River !; also at the Goyder River ! and Hamilton River (Stuart).

Eragrostis laniflora, *Bentham.* Common on sandy ground among *Triodia*, Idracowra and northward, plain off George Gill Range !.

Eragrostis eriopoda, *Bentham.* Bagot's Creek !.

Eragrostis falcata, *Gaud.* Alice Springs and Charlotte Waters (C. Giles); also at the Goyder and Stevenson Rivers !.

Triraphis mollis, *R. Brown.* Alice Springs and McDonnell Range (Giles). Widely dispersed throughout the district, also at Crown Point !.

Triraphis pungens, *R. Brown.* Bagot's Creek Gorge !; has the habit of *Triodia pungens*, the leaf-sheaths are slightly woolly.

|| Arundo Phragmites, *Linné.* Hermannsburg (Kempe). Henbury; Bagot's, Reedy and Palm Creeks !.

RHIZOSPERMÆ.

|| Marsilea quadrifolia, *Linné.* Clayey banks of creeks and loamy flats subject to inundation, widely diffused !.

LYCOPODINÆ.

*|| Psilotum triquetrum, *Swartz.* Rocky clefts over-hanging rock-pool at Reedy Creek !.

FILICES.

*|| Lygodium reticulatum, *Schkuhr.* McDonnell Range (*fide* F. v. M.).

*|| Adiantum hispidulum, *Swartz.* Rocks by waterhole at Reedy Creek !.

*|| Cheilanthes vellea, *F. v. M.* McDonnell Range (E. Giles), Krichauff Range (Kempe), Mount Sonder (Tietkens), Mount Tate !.

*|| Cheilanthes tenuifolia, *Swartz.* A common rock-fern throughout the region !. Recorded by Kempe and Tietkens.

|| Aspidium unitum, *Swartz.* Marsh by waterhole Reedy Creek, and by Penny Springs in Penny Creek !.

* Grammitis Reynoldsii, *F. v. M.* Shaded rocks in Stuart's Pass !.

*|| Grammitis rutæfolia, *R. Brown.* Finke Gorge !.

6. Diagnosis of new Genus and Species.

Acacia Cowleana, Tate.

Slender, erect, about six to eight feet high; the foliage and young branchlets, ashy or hoary with very minute appressed hairs. Branchlets stout, acutely trigonous. Phyllodia lanceolar-falcate, narrowed at both ends, mostly five to seven inches long and three-fourths wide at the middle, coriaceous, with three prominent parallel veins, the interspaces with eight to ten secondary veins which frequently anastomose. Stipules minute lanceolate. Spikes shortly pedunculate, one or two together, up to two inches long. Flowers distant or distinct, pentamerous. Calyx very much shorter than the corolla, minutely pubescent, with five short blunt denticulations.

Corolla deeply five-cleft, smooth; each segment narrow, oblong, with an apiculate tip; yellow, brown at the base.

Ovary pubescent. Pod (not seen ripe) exceedingly flat, long and narrow, four to five inches long, and one-seventh wide, not twisted, glabrous or nearly so.

Seeds longitudinal; funicle very long and slender, loosely double-folded at about the middle, beneath the seed.

The species name is in compliment to Trooper Cowle, who conducted a section of our party to Mount Olga, and in various other ways promoted the scientific objects of the Expedition.

Among members of the series Juliforæ, this new species finds a place in the section Falcatæ near to *A. glaucescens* and *A. Cunninghamii;* from the second it differs by its straight pod and thus resembles the former; from *A. glaucescens* it differs by its very long smooth pod, oblong-apiculate petals and by coarser anastomosing secondary venation.

Acacia frumentacea, Tate.

A small tree attaining ten or fifteen feet high, glabrous and mealy glaucous; branchlets somewhat angular. *Phyllodia* narrowly oblong, apex obtuse, with a minute tip recurved over a subterminal gland, narrowed at the base, two to three inches long, coriaceous, with a prominent mid-rib and distinct reticulate veins, pale green. *Peduncles* slender in axillary racemes, shorter than the phyllodia; heads globular of about forty flowers, mostly tetramerous. *Sepals* very narrow linear, slightly spathulate at the end, smooth, free. *Petals* distinct or almost so,

smooth, lanceolate-oval to oval-oblong, about twice as long as sepals. *Pod* oblong, flat, obtuse, one and half inches long by one-quarter or three-eights wide; valves membranous. *Seeds* about six, transverse, thick, depressedly orbicular to oval-oblong, impressed above and below; estrophiolate; funicle short, once or twice folded under the seed.

This species in its foliage, flowers and fruit approaches *A. leptopetala*, but seems to differ by more distinct neuration of the phyllodia, by its tetramerous flowers and flattened seeds. It has some affinity with *A. sentis*, but the seeds are not globose, and stipules are absent.

Didiscus Gillenæ, Tate.

Herbaceous, apparently annual, acaulescent with radical erect leaves and decumbent simple peduncles, spreading to one or two feet; when dwarf the peduncle is erect. Leaves on long petioles, deeply five-lobed with cuneate three- or five-lobed divisions, sparsely covered with long soft hairs.

Peduncles two or three times exceeding the leaves, simple; umbel of numerous flowers on relatively long pedicles. Involucral bracts herbaceous, linear-lanceolate with setiferous tips and margins, as long as the flowers and distinctly united at the base.

Flower-head 10 to 20 mm. diameter; flowers very numerous on slender pedicles of 5 or more mm. long, calyx tube red; petals whitish above and pink beneath; anthers red.

Fruiting pedicels exceeding the involucral bracts; carpels slightly laterally compressed, densely covered with simple bristly pinkish-red hairs having a thickened base; one carpel usually larger than the other, oval, about 2 mm. high and less in width; seed slightly compressed.

In its bristly carpels this new species resembles *D. cyanopetala* from which it differs in denser umbels, well-developed pedicels, longer leaf-stalks, colour of flowers and carpels.

The dedication is a slight mark of tribute to Mrs. F. J. Gillen's hospitality, which was enjoyed by the author and other members of the Expedition.

Wedelia Stirlingi, Tate.

Erect, rigid, often two feet high. Leaves linear-lanceolate, acuminate, toothed. Peduncles rigid, up to six inches long, solitary. Involucres hemispherical, about

quarter-inch diameter, the bracts oblong acute. Ray-florets quarter-inch long. Scales of the receptacle acute. Achenes winged and tuberculate. Pappus not cupped, reduced to a bristle or two at the end of the wings.

This new species belongs to that group in which the outer involucral bracts are similar to the inner ones, and of these to those in which the pappus is reduced to one or two bristles. It, however, resembles most *W. spilanthoides* in its long rigid solitary peduncles. From *W. biflora* and *W. asperrima*, it is separable among other characters by the winged and tuberculated achenes.

Goodenia Horniana, Tate.

Stem erect, woody, usually branched, not exceeding one foot. Leaves softly but minutely glandular-pubescent or tomentose, rhombic-oval, coarsely serrate, half to three-quarter inch diameter, on petioles about as long as the blade. Peduncles axillary, slightly shorter than the leaf-stalks, one-flowered, with a slender linear bracteole below the middle. Calyx-lobes linear-lanceolate, glandular-pubescent. Corolla large, about one inch long, bluish-white streaked with purple, silky pubescent outside, hirsute inside, but the auricles smooth inside and outside; the two upper lobes more deeply separated, all the lobes broadly membranously winged, the adnate part of the tube with a slight baccate protuberance. Style almost as long as the corolla, silky-hairy throughout its length; stigmatic cover purple, smooth or with a few hairs at the base, fringed with short erect white hairs at the orifice. Capsule about half-inch long; dissepiment reaching about two-thirds the length of the capsule; seeds several in two rows, small, orbicular, flat, shining brown, minutely granular, with a narrow smooth thickened margin.

This species comes near *G. grandiflora* and *G. Chambersii*, from which it conspicuously differs by the violet (not yellow) colour of its flowers and by the presence of distinct bracteoles.

Goodenia Larapinta, Tate.

An erect, unbranched, viscid-villous herb, about one foot in height. Leaves oval-lanceolate, distinctly serrate, sessile. Peduncles one-flowered, axillary, longer than the subtending leaves. Bracteoles none or filiform and minute. Calyx-lobes linear-lanceolate. Corolla about half-inch long, the three lower lobes broadly winged; the two upper ones separated much lower down than the others, shorter, narrower, less broadly winged, but with an auricle on the outer margin below the middle. Style under quarter-inch long, smooth; the stigma cover smooth, except

a few scattered white long hairs and the terminal fringe of dense short ones. Capsule cylindrical, oval-oblong, half-inch by quarter-inch; dissepiment fully half as long; seeds small, several lenticular, dark brown, minutely granulated, with a narrow thick whitish margin.

This species has the habit and the floral characters of *G. heterochila*, but its viscid foliage approximates it to *G. sepalosa*, though it has not the leafy calyx-lobes of that species. It differs from both by its cylindrical capsule, relatively long dissepiment, lenticular (not flat) seeds and corolla-lobes not so much dissimilar.

Elacholoma. F. v. M. and Tate.

Calyx campanulate-ovate, its five lobes much shorter than the tube. Corolla filiform-tubular, very much narrower than the calyx, widened only at the summit; lobes minute, almost inperceptible. Stamens two, short-exserted; anthers almost reniform, ex-appendiculate, dorsi-fixed, bursting anteriorly, their two cells confluent. Style fully as long as the corolla, very thinly filiform. Stigmas two, conspicuous, divergent, capillulary. Ovulary two-celled, without any parietal intrusion beyond the dissepiment. Placentaries axillary, somewhat projecting. Capsule turgidulous-oval, loculicidal-dehiscent. Seeds numerous, very minute; hilum basal; albument conspicuous; embryo straight.

A minute annual herb, whitish-grey from tomentellous vestiture; leaves linear, scattered or the lower opposite; flowers sessile, axillary, solitary but somewhat crowded at the summit of the stems.

Elacholoma Horni, F. v. M. and Tate.

An erect or diffuse herb, four inches or less high. Root rather copiously fibrous. Leaves extremely narrow, hardly acute, slightly kelled, concave above, flaccid, from one-third to two-thirds of an inch long. Calyces measuring about one quarter of an inch in length, longitudinally five-streaked; their lobes deltoid semi-lanceolar, finally converging. Corolla glabrous, seemingly dark-coloured; its upper portion emerged. Stamens, ovulary and style glabrous. Stigmas subtle-papillular. Capsule about one-sixth of an inch long; the pericarp of almost membranous texture, its dehiscence nearly bivalvular. Seeds brown, truncate, ovate, almost smooth. Embryo nearly ellipsoid.

This Scrophularinous genus recedes from all others of that order in the extraordinary thinness and almost lobelessness of the corolla within an inflated calyx, and differs more particularly still in its comparatively long and quite capillulary stigma divisions, by which some approach of this genus to the Sesameæ is indicated.

XANTHORRHŒA THORNTONI, Tate.

Caudex attaining to a height of six feet and a circumference of three. Leaves slender but rigid, four feet long, strictly quadrangular, about two millimetres in diameter, interstriated (about nine striæ on each face); margins acute, minute crenate-serrate. Scape seven feet long, inclusive of the spike which is five and a half feet. Inner bracts crustaceous, oblong, obtuse, undulate on the margins, smooth and shining, without veins, about half the length of the capsule. Outer bracts linear with spathulate tips, without veins; the outermost ones with broadly decurrent bases. Flowers not seen. Capsule one inch or more in length; the valves broadly lanceolate, abruptly narrowed into a long somewhat pungent-pointed tip; the upper-half of the outer face finely longitudinally furrowed. Seeds oblong-elliptic in longitudinal outline, acutely triangular in transverse section, black, minutely granulated; outer face convex, longitudinally ridged; the inner narrow faces separated by an acute medial ridge.

The species name is in compliment to Mr. Thornton, late of Tempe Downs, who at considerable trouble was the first to bring this grass-tree to my notice, and in other directions greatly forwarded the objects of the Expedition.

This species by its foliage resembles the southern *X. quadrangulata*, from which it conspicuously differs by its scape, very much shorter than the spike; also by its longer and narrower capsule, and relatively shorter subtending bracts. *X. Preissii*, to which it is geographically nearest, is somewhat intermediate between *X. Thorntoni* and *X. quadrangulata* as regards the proportionate length of the flower-bearing portion of the scape; but the foliage among other characters is different.

CHAPTER II.—The Central Eremian Flora.

1. PHYSIOGRAPHIC AND BOTANIC CHARACTERISTICS OF THE REGION.

That portion of the central Eremian region travelled over by the Expedition from Oodnadatta to Engoordina, by way of Dalhousie Springs on the out-journey, and back by way of the River Stevenson, has been fully well explored for its botany. And though every opportunity was availed of, yet only a very limited number of species is worthy of note, some because new to the region (including one, *Threlkeldia proceriflora*, previously unknown in South Australia), others because reaching their most northern or southern limits in the meridional direction,

whilst a few are recorded because of their rarity. Some of the species have already been mentioned as occurring in the Larapintine area.

The vegetation of this section of the country embraces that of the *flood-ways* of the rivers and creeks, particularly the delta-like reticulation of the Stevenson River north of Macumba, that of the *sand-hills* and that of the *gibber-fields*.

By far the richest flora as regards numbers of species is that found along the margins of the water-channels at their lower elevations; here *Eucalyptus microtheca*, *Acacia aneura*, *A. cyperophylla* and *A. homalophylla* are conspicuous; and in favourable seasons a varied and luxuriant growth of grasses prevail.

The sand-hills yield a considerable variety of annuals after copious rain, but *Triodia* is rarely present and only as *T. irritans* (when accurate determination was possible), but *Spinifex paradoxus* is common.

However, the most prominent physiographic feature is that of the "gibber-fields," which are most characteristically exhibited from near Macumba to Charlotte Waters. The gibber-fields which are, probably, of the same nature as the "stony desert" of Sturt, are co-extensive with the area in which the outcropping surfaces of Cretaceous beds have been altered to a hard splintery rock by infiltration or by substitution of chalcedonic or opaline quartz. Where this kind of rock occurs, usually as a crown to tabular elevations, the surface around is thickly strewn with its broken fragments, ranging from blocks of several cubic feet to road-metal size, and graduating to smaller dimensions with increasing distance from the source of supply; among the stones and beneath them is a red loess. At some points could be recognised the sources whence the *gibbers* had been shed, whilst more extensively the original stores have been exhausted. At the times of our traverses, the *gibber-fields* offered the most desolate aspect—the annuals had disappeared and the shrubby vegetation had been reduced to the condition of skeletons of dried branches and twigs; though, from traces of herbaceous plants, it may not be unreasonable to infer that after copious rains an ephemeral vegetation may be comparatively abundant, it can never be absolutely abundant because of the very limited space available by reason of the crowding of the gibbers.

Here follows a list of the plants observed around Mount Squire, twenty miles north from Crown Point, the most northly extension of this type of country:—

Lepidium papillosum	Helipterum Fitzgibboni
Frankenia lævis	Helipterum Tietkensi
Salsola kali	Brachycome ciliaris

Bassia bicuspidata
Acacia aneura
Acacia tetragonophylla
Acacia Kempei
Cassia desolata
Ptilotus incanus
Eremophila Freelingi
Hakea leucoptera
Fimbristylis communis
Diplachne loliiformis
Triodia sp.

A more typical collection is that afforded by the following list observed on the table-land, about 700 feet elevation, at about five miles south from Charlotte Waters, and also between Blood Creek and the Stevenson River:—*Atriplex rhagodioides*, *Salsola kali*, *Kochia aphylla*, *Eremophila Freelingi*, *Bassia diacantha*; *A. rhagodioides* is the prevailing shrub, but where the stony surface gives place to friable loam then *K. aphylla* is dominant, where the surface is channelled by water-runnels their courses are indicated by lines of the shrubs or small trees of *Acacia aneura*, *A. cyperophylla* or *A. homalophylla* and with them *Cassia desolata*. Among bare patches of loam the following were noted:—*Lepidium papillosum*, *Frankenia lævis*, *Euphorbia Drummondi*, *Boerhaavia diffusa*, *Ptilotus exaltatus*, *P. incanus*, *Tragus racemosus*, *Cynodon ciliaris*, *Sporobolus actinoclados*, *Eleusine cruciata*, *Aristida arenaria*, *Pappophorum commune* and *Astrebla pectinata*.

2. List of Plants, New or Rare in the Region.

[The asterisk prefixed indicates that the species is New for the Region.]

*Drosera Indica. Wet banks of the River Stevenson.

Hibiscus Krichauffi. Common from Oodnadatta to Crown Point.

Rumex crystallinus. River Stevenson between Oolabarrinna and Macumba.

*Atriplex elachophyllum. Crown Point and Adminga.

*Threlkeldia proceriflora, a hirsute variety. Adminga. New for South Australia.

Kochia brachyptera. Adminga.

*Bassia salsuginosa. Adminga.

Crotalaria Mitchelli. Sandy loam-flats by the Stevenson River, from Oolabarrinna to Macumba.

*Acacia homalophylla (giddea in the vernacular). Forms a dense scrub around base of Mount Daniel; margining water-channels from Charlotte Waters to Oodnadatta. Conspicuous by its ashy-grey foliage.

Tetragonia expansa. River Stevenson.

Loranthus grandibracteus. Parasitic on *Eucalyptus microtheca*, margining water-channels from Oodnadatta to Ike's Well on the Stevenson River; also Red Mulga Creek near Dalhousie Springs.

Flaveria australasica. Giddea Creek near Oodnadatta.

Hyalolepis Rudalli. River Stevenson near Macumba.

Gnephosis arachnoidea. Crown Point, River Stevenson near Macumba.

Pepilidium Muelleri. River Stevenson near Macumba.

Bulbine semibarbata. Clay-pans about the Lower Stevenson River.

*Triglochin procera. Water-holes near Oodnadatta.

Panicum reversum. Finke River at Crown Point.

Anthistiria membranacea. Giddea Creek near Oodnadatta.

Eragrostis concinna et E. leptocarpa. By water-holes on the Lower Stevenson River.

APPENDIX.

Notes on some Vegetable Exudations.

By J. H. MAIDEN, F.L.S.

Professor Tate has placed in my hands for examination, the Vegetable Exudations collected during the Horn Expedition. The samples were quite small, and an exhaustive examination of most of them was therefore out of the question, but they are of scientific interest, particularly in view of our scanty knowledge of authentic substances of this character, especially from the interior of the continent. The collection of such substances in the interior must necessarily be a slow process, as the gums are washed off the trees by the first shower of rain, the astringent exudations are affected both by the rain and by the fierce rays of the sun which induce changes in their composition, while the resins readily dry up, become brittle, fall to the ground and are lost.

No. 1. "Portion of an ant's nest, consisting of sand agglutinated by gum from *Triodia pungens*, formed around the base of the grass, and continued as cylinders around leaves and flower stalks. Tempe Downs." This substance has the appearance of a lump of reddish-brown clinker. When treated at a very low temperature the resin melts (even in the flame of a match), and in its crude state would make a useful cement. When the resin has burned away, the residue consists of sand, principally quartz coated with ferric oxide, the latter being removed by dilute hydrochloric acid. This ferric oxide assists to give the original mass its reddish-brown appearance. When the original substance is treated with alcohol (rectified spirit), the resin readily dissolves, leaving the sand, which differs in no way from that obtained by burning off the resin. Ether dissolves the greater portion of the resin, but instead of the residual resin being dark brown as in the case when alcohol is used, it is of a golden yellowish colour, and when ignited burns away without residue, while that portion extracted by alcohol after the ethereal extract has been removed, leaves a small quantity of residue.

The bright yellow resin melts at 83° C. The original resin extracted by alcohol melts at 110° C., while the alcoholic residue left on removal of the resin soluble in ether does not melt at 140° C. It consists partly of inorganic material. As it was present in small quantities, its composition could not be

determined in the small portion of material forwarded. The resin obtained from *Triodia irritans*, R. Br. by ether, in appearance and colour resembles that obtained from *Triodia pungens*, but it has a lower melting point, melting at 63° C. The brown resin obtained by alcohol, corresponding to that obtained by alcohol from *Triodia pungens*, melts at 102° C. From the results of the examination of the bodies contained in the resinous material of *Triodia irritans* ?* it was suggested that the fat found was artificially introduced; its presence would lower the melting point of the resin. Judging from the appearance of the two resins, their colour, odour, melting points, etc., there appears to be but little difference in the resins obtained from *Triodia pungens* and *Triodia irritans*, and they may prove to be identical when prepared under similar conditions.

We have so few records of the finding of the Porcupine resin, that the following is of interest:—"Samples of resinous matter from roots of Spinifex, and tunnels made by ants, found here for the first time, lying on the surface of the sandy ground between bunches of Spinifex, apparently made of sand cemented with some agglutinous secretion of the insect, or, what is more probable, the resinous substance found at the roots of the Spinifex plant." (W. T. Tietkens' Exploration of West Central Australia, in Trans. Roy. Geog. Soc. Vict., viii., 35).

No. 2. Gum of *Atalaya hemiglauca*, F. v. M., Central Australia. Most of this gum is quite colourless, and adherent to pieces of the wood of the tree, which belongs to the natural order Sapindaceæ. A very small quantity only was received. It is readily soluble in cold water, from which solution alcohol throws down a white precipitate readily soluble in water but insoluble in alcohol, and resembling arabin in its properties. It is pure gum and appears to differ little from the purest Gum Arabic. A portion of the gum is also attached to a covering of the exterior of the bore of a wood moth (probably a species of *Cryptophasa*) made of silken web, with castings and debris attached. This gum would be a valuable article of commerce if obtainable in quantity.

No. 3. Kino of *Casuarina Decaisneana*, F. v. M., near junction of Rivers Finke and Palmer. The material, received 26th April, 1894, consisted of portions of the tree coated with a dark brown resinous looking material which substance also filled the hollows of the lumps. At places it had a varnishy appearance, but the greater portion was a dull dry looking mass of an umbery colour. When powdered and treated with water a reddish-brown solution is obtained, which consists principally of a tannic acid giving a dirty purplish colour with ferric chloride and precipitable

* See a paper by me on "Spinifex resin," Proc. Linn. Soc. N.S.W., (2), vol. iv., p. 639, 1889. (A gum used by the blacks for cementing the ends of spears and prepared from Spinifex roots). Collected at Napier Range, W.A.

with gelatine and acetate of lead. With boiling water the solution is fairly clear, but becomes turbid on cooling, from the presence of a body insoluble in cold water. The material was too small in quantity to enable this body to be satisfactorily determined. The residue left after treatment with water was partly soluble in alcohol and consists of phlobaphenes insoluble in water but soluble in alcohol. In alcohol the colour of the solution is much darker from solution of the phlobaphenes. When this alcoholic solution is evaporated to dryness it has but the slightest solubility in water, but is readily soluble in dilute ammonia from which solution the phlobaphenes are precipitated on addition of acetic acid. It is one of those astringent exudations so common in Australia, usually designated "inspissated sap." A sufficient quantity of pure material is difficult to obtain, and an exhaustive examination of it remains a desideratum.

No. 4. Roots of *Leschenaultia divaricata*, F. v. M., Central Australia. "Gum extracted therefrom used by the aborigines as a cement." [*Scaevola depauperata* and *Spinifex paradoxus* are similar.] These roots consists of two parts—an inner very tough woody portion consisting almost entirely of cellulose, and an outer tube which readily slips off the inner string-like portion. This outer tube is covered externally with fine sand, cemented into the material forming the basis of this outer covering. The diameter over all is from 8 to 3 mm., the inner portion being 1 mm. When treated with alcohol virtually nothing dissolves, the particles of sand not being loosened in the least. When treated with water, but a very minute portion of a gummy material dissolves; this is precipitated by alcohol, is brittle when dry, and readily soluble in water. No ordinary solvents dissolve the coating holding the sand particles, these roots consisting almost entirely of cellulose and allied substances, and it is not clear to me how, as stated, the aborigines extract a material from the roots for cementing purposes. Further information upon this point is certainly required.

No. 5. Flaky fibrous bark of Red Mulga, *Acacia cyperophylla*, F. v. M., collected 9th May, 1894. Shrubby tree to thirty feet high, the red bark peeling off in thin shavings. This specimen consists of very thin, flaky, fibrous portions of the bark, and is very slightly astringent. The portion submitted evidently consists of the external portion of the bark, and is similar in character to that often found in dry country Acacia barks. The bark is not likely to be of commercial value, and the portion received does not appear to be of special scientific interest. It consists almost entirely of cellulose.

I desire to record my obligations to Mr. H. G. Smith, my assistant, for help in the preparation of these notes.

ALPHABETICAL INDEX TO PART III.—GEOLOGY AND BOTANY.

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